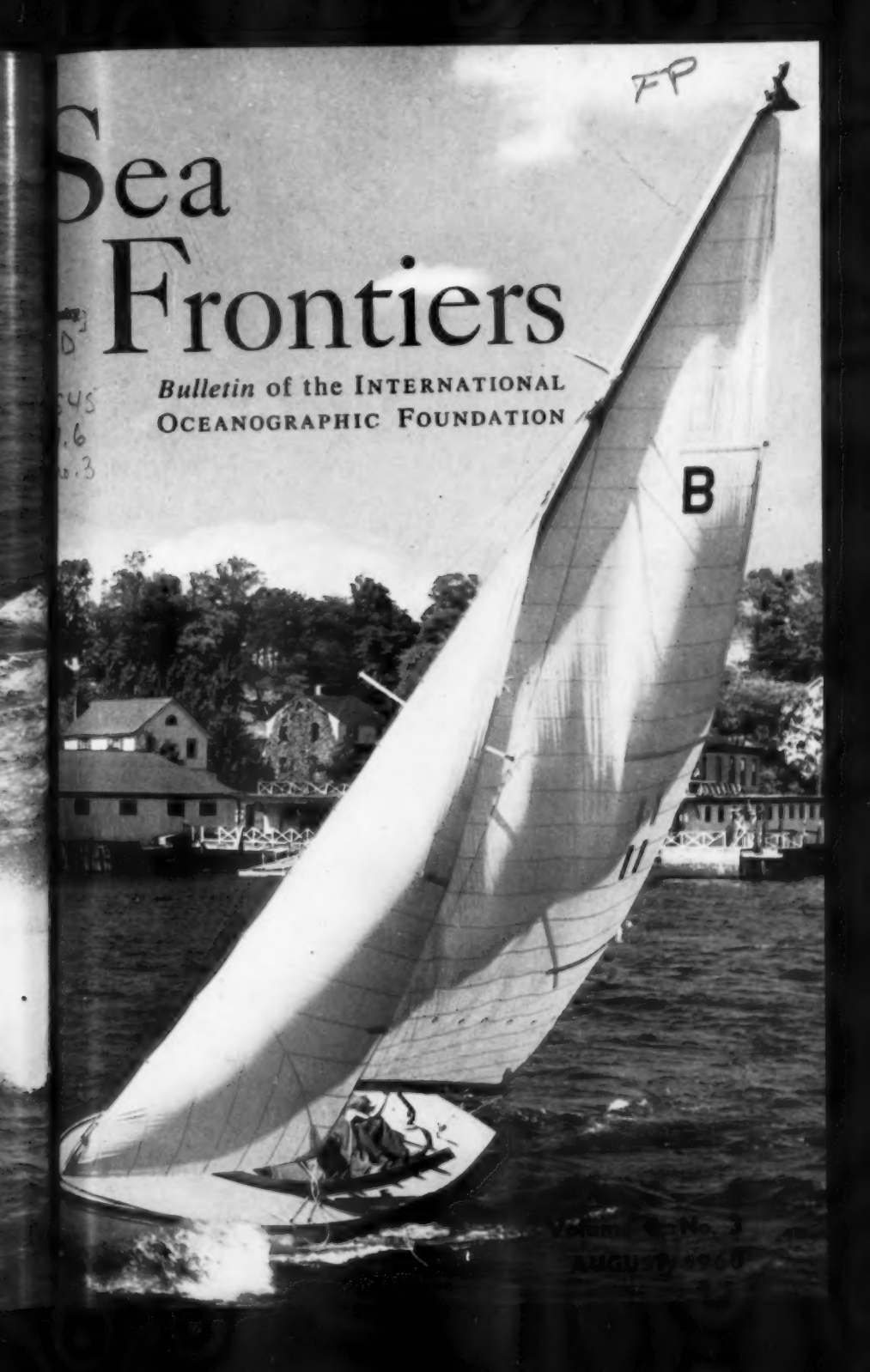
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Frontiers
Bulletin of the INTERNATIONAL
OCEANOGRAPHIC FOUNDATION
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HUNTING FOR THE PROVERBIAL NEEDLE? *No, this is not a haystack, but ten years of marine growth which accumulated on a buoy that had been sunk by a passing ship. Coast Guardsmen scrape off the thick covering of barnacles, moss, and seaweed at their Portsmouth, Virginia, base. Marine biologists have studied these growths in order to develop better antifouling paints. (U. S. Coast Guard)*

FRONT COVER. FULL SAILS TO THE SUMMER BREEZE. *A yacht racing in Halifax's picturesque harbor indicates the love of Nova Scotians for the sea and ships. Halifax is not only one of Canada's principal commercial fishing ports, but it is not far from the Bay of Fundy, which has the world's highest tides. (Nova Scotia Film Bureau)*

BACK COVER. THE HOOKED FURY *of a tarpon, one of the sportiest of game fishes. This big beauty, with its gills distended, was caught in the Ten Thousand Islands section of Everglades National Park, Florida. Many game fishermen have aided science by making their catches available for study in laboratories. (John Mahony, ©)*

SEA FRONTIERS

Bulletin of the INTERNATIONAL OCEANOGRAPHIC FOUNDATION

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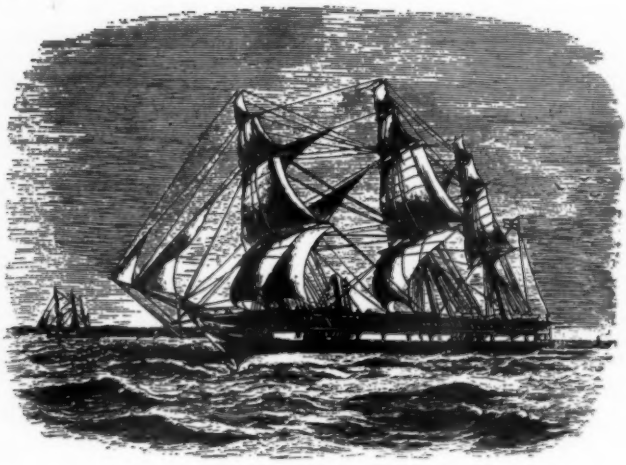

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Engineering Industry Turns to the Sea

WHILE BIG INDUSTRY continuously seeks to become more diversified, in recent years, and perhaps rightly so, the advance guard and specialists of American engineering have concentrated their best efforts on keeping the nation ahead in the development of rockets, guided missiles and satellites, as well as in the older established fields of mining, manufacturing and transportation machinery.

Plateau in Sight

As successes in rocketry begin to outnumber failures, however, and as more and more companies enter this once highly specialized endeavor, many large engineering firms realize that a plateau may soon be reached. Orders may be curtailed, too, as equipment and products become standardized. Manufacturers of railroad and mining machinery among many others are also aware of long-term trends that may limit too specialized types of operation.

Several leading concerns, now heavily engaged in meeting the needs of the so-called "space age," are therefore beginning to ponder about the eventual need of greener pastures. Specific developments are slow to arise, but in private conversations, taking place in yacht and country clubs, fishing and hunting lodges, and in other places where big executives congregate, the phrase is "inner space"—the ocean!

Tapping Untold Wealth

In other words, there seems to be a growing conviction among top business interests that the next big frontier in the world of engineering will be in tapping the untold wealth of the sea, an activity in which industrial firms will play an important role—in electronics and acoustics, as well as in heavy engineering. This turn of events will require not only specialized equipment and skills, but also more fundamental knowledge of the nature of the ocean—marine life, currents, salinity, mineral content, radioactivity—so that it is inevitable business leaders will have to turn to the major oceanographic stations and foundations of the world.

Already inquiries have been coming into some of the larger and more diversified marine laboratories, asking

DY IN CONTRASTS — U.S.S.R. AND A.! *During the First International eanographic Congress, held at the ited Nations in September, 1959, re- rch vessels of various nations were exhibit at a Hudson River pier. Here bow of the Soviet vessel* Mikhail monosov, *largest (5,960 tons) oceano- phic research ship in the world, ms over the stern of* U.S.N.S. Gibbs, *eground) largest (2,800 tons) U. S. earch ship. (Bernard L. Gordon)*

about the engineering requirements for obtaining more metals, food, chemicals and even fresh water from the oceans, the mantle which covers more than three-quarters of the surface of the globe.

Industries Already at Sea

A surprisingly large number of industries are already tied in with the sea. One need only mention shipbuilding, navigational equipment such as radar and loran, off-shore mining for sulphur and oil, and, of course, commercial fishing. These involve such diversified scientific problems as corrosion, shipbottom fouling, underwater sound, and the geology of the sea floor, all of which are the immediate concern of oceanographic laboratories.

Other astute commercial interests recognize an urgent need for focusing more of our defense efforts on the rather obvious menace presented by the world's largest submarine fleet of Soviet Russia. To meet this threat the free world must have, of course, the best in anti-submarine equipment, which ranges from its own hunter-killer subs and intricately equipped surface vessels, to helicopters, blimps and buoys rigged with delicate sonic devices.

Mysterious Layers

Marine scientists must also come up soon with some answers to those mysterious layers in the sea where enemy submarines could lurk undetected by any existing listening mechanisms. There are regions such as the thermocline, for instance, a layer of rapid temperature change, 450 to 600 feet below the surface; or the deep scattering layers, which are really concentrations of plankton, causing misleading echoes on listening devices. Once known as the "false bottom," scattering layers range from 1,500 to 6,000 feet down, and they may rise and fall with darkness and daylight.

Probing these vital areas and the contours of the sea bottom are very expensive investigations, requiring ships costly to operate, and the services of high-paid staffs. American industry, as well as government, may be expected to undertake some of the engineering problems involved, not only for the common good but in anticipation of their eventual diversification in the direction of an industrialized ocean.

Some Real Progress Made

Oceanography's future for industry, in fact, holds many exciting possibilities. Already progress has been made in obtaining various salts, magnesium and other minerals directly from sea water, while bromine has been secured as a valuable by-product of both salt and magnesium production.

What about the prospect of obtaining minerals in solid form from the sea bottom? Several such deposits have been found, at varying depths. However, they are not formed like land ores, but in nodules made up of materials which have washed into the sea in ages past and adhered to pieces of clay, pumice, volcanic glass or even shark's teeth or bone. It is estimated that their value, in certain areas, may run as high as $500,000 per square

SULPHUR MINES PUT OUT TO SEA. *This is how an expansion of the "Texas Tower," also used for offshore drilling for oil and as radar listening posts, puts science to work in tapping rich sulphur deposits in the Gulf of Mexico, off Grand Island, Louisiana. Some $30,000,000 worth of facilities stand on steel stilts sixty feet out of the water (to avoid hurricane waves), and includes air-conditioned housing for workers, T.V. rooms, cafeteria, and a heliport. (Freeport Sulphur Company)*

mile. A king-size, but not impossible engineering job faces those who would bring the nodules to the surface on a commercial scale.

Greatest Need—Fresh Water

As the world's exploding population demands more and more fresh water, not only for drinking and washing, but also for the making of steel, paper and other products, the sea is the logical and only unlimited source of the basic elements. Industry, with the encouragement of the Office of Saline Water, Department of the Interior, has been attacking the problem of salt water conversion into fresh water from several angles, and already nearly a dozen processes have been tested. As more atomic reactors become available, providing concentrated power on islands or stretches of lonely seacoast, sea water conversion may be extended to areas otherwise desirable but lacking in fresh water.

Much research remains to be done on both surface and sub-surface navigation, including the use of inertial guidance, and methods of acoustical communication. In the not-too-distant

WHALE-LIKE OIL CARRIER. *The flexible Dracone during tests in New York harbor showed that it can transport 10,000 gallons or more of oil. Hitched to a standard tanker, the Dracone can double the tanker's capacity with a speed reduction of only 25 per cent. It can be deflated for the return voyage and carried on deck. This is another way in which industry is finding in the sea a valuable ally.* (New York Times)

future, American oceanographers will be exploring the ocean floor in an aluminum research-type submarine, appropriately named the *Aluminaut*. A private undertaking of the Reynolds Metal Company, of Richmond, Virginia, the *Aluminaut* will be leased to oceanographic institutions for specific research purposes.

RUM and Dracones

While the U.S. Navy's bathyscape reached a record depth of 35,800 feet in the Pacific, gaining world-wide headlines, not a great deal of scientific information was obtained. Much more promising is another vehicle for exploring the ocean's floor. Dubbed "RUM," for Remote Underwater Manipulator, the device is really a remote-controlled, unmanned tank, equipped with a long, jointed manipulator arm and hand, together with underwater TV cameras which serve as eyes for the operator on shore. It is undergoing undersea trials off La Jolla, California.

Oil and sulphur industries have reached far out beyond the ocean's shoreline to tap new sources of these minerals from "Texas Towers," which are also used as radar warning posts by the Department of Defense. The oil industry is interested, too, in a recently-developed rubber underseas barge, called "Dracone."

Built by a British firm, the "Dra-

cone" is a flexible, partly submerged oil carrier which looks like a whale, but can transport 10,000 or more gallons of oil. It is claimed that by the use of "Dracones" a standard oil tanker can double its capacity with a speed reduction of only 25 per cent.

New Ship Designs

Research vessels for oceanic studies are moving far afield from conventional ship design. Of South Pacific origin, the catamaran (twin-hull) offers amazing versatility in the exploration of shallow waters and reefs. A trimaran (triple-hull) is also undergoing sea tests. Water-jet and air-cushion devices give promise of more new methods of propulsion. The hydrofoil's capabilities still are largely untapped.

These and countless other developments in marine fields present a real challenge and possibly some help to industry. That there is an awareness of opportunities in the sea was borne out recently during a meeting held at the Foundation's headquarters, when assembled scientists and engineers discussed the formation of a special section of the Institute of Radio Engineers for the study of oceanographic electronics. Quite a number of large corporations, such as U. S. Industries, are now making oceanographic instruments and experimental marine devices, and studying the feasibility of major engineering projects in the sea.

Big Dividends Result

It is significant to note that wherever money has been spent in the past to outfit and encourage marine laboratories, oceanic research vessels and marine studies, big dividends have eventually resulted. This has been true in Britain, Norway, Japan, France, Portugal, Iceland and the Soviet Union, although most of the research work done in these nations has been by government subsidy.

There is no reason, of course, why American business and industry should have to wait for the slow wheels of peacetime government progress to revolve. The vast and largely untapped resources of the sea are immediately available, and many corporations have reserve funds to provide the initial financing. Meanwhile, the International Oceanographic Foundation is already making plans to extend the exchange of information between oceanographers and industrialists.

Closer Liaison Needed

The Foundation believes that closer liaison between science and industry might hasten the time when we shall make full use of the ocean's resources. It therefore places its services at the disposal of industry to provide access to the most up-to-date information. Much useful data already are at hand.

The Foundation also is making plans to sponsor next year a special meeting of industrial representatives and oceanographic scientists, at which the needed liaison and transfer of information may be initiated. Inquiries and suggestions regarding this will be welcomed.

Little Monsters of the Deep

By F. G. WALTON SMITH
Director, The Marine Laboratory
University of Miami

THERE IS A public appetite for the unconfirmed but perennially revived reports of sea serpents and other fabled giants of the sea. Yet, in the deep ocean waters there are real monsters in many ways more fantastic than the legendary ones, though familiar only to scientists. However, their monstrosity lies not in size, for most are measured in inches and none are more than three feet long, but in their strange forms and habits, brought about as a result of the peculiar conditions under which they live.

Eyes on Tubes!

In the dark cold deeps prowl weird creatures with built-in fishing lures, focussing searchlights, telescopic eyes, and great mouths that unhinge to take in gargantuan meals. Others discharge luminous clouds, the counterpart of inky substances in clear water, to protect or hide themselves.

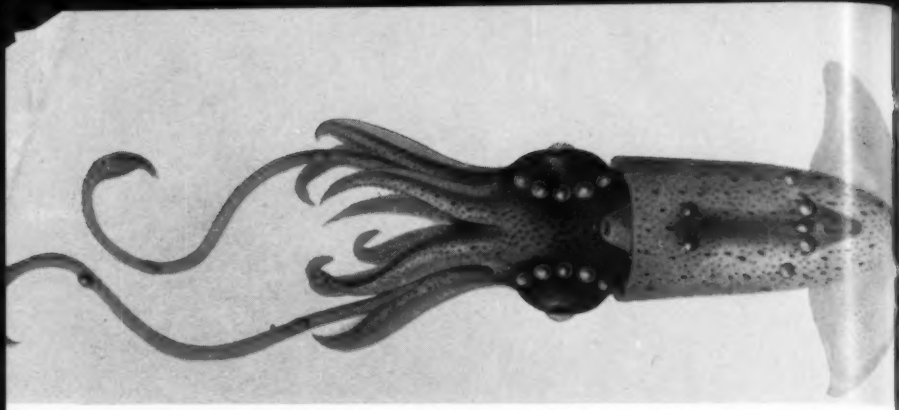
Consider, for instance, the squids. The giant squid, *Architeuthis,* is remarkable mainly for its great size, which with outstretched tentacles, may exceed fifty feet (*Sea Frontiers,* Vol. 5, No. 3). In contrast, there are many small squids, less than eight inches long, to whom life in the eternal dark of the abyssal depths has brought strange and curious modifications. The bodies of most of them are studded with the dim glow lamps of luminous organs, which can be lit up or extinguished at the will of the animal. Some of them have eyes mounted grotesquely on the ends of tubular projections.

On the other hand, a deep sea octopus, *Cirrothauma murrayi,* has eyes which have almost completely degenerated. Not only is it blind, but the web of skin between its arms gives it the appearance of an inverted parachute, while two fleshy outgrowths resemble floppy ears. Except for size, it far outranks the giant squid for sheer monstrosity.

Meals Few and Far Between

This strange appearance of the creatures of Stygian depths is, of course, related to environment. Below 2,000 feet there is no appreciable sunlight, the water is very cold and relatively motionless, and the supply of food is scarce compared with the higher levels of the sea. Monstrous

AS RECENTLY AS 1843, *Edward Forbes, ioneer marine biologist, as a result of redging on* HMS Beacon *in the Aegan Sea stated that animal life would ot be found below 300 fathoms (1800 eet). Later research revealed that many arts of the great depths contain living reatures such as this gaping melanotomiatid. Head-on it looks monstrous, ut it seldom exceeds eight inches in ength. Its generic name is* Chirostonias pliopterus, *and it was caught at a epth of 500 fathoms off Bermuda.* Zoologica, *1939*)



THIS SQUID LIGHTS ITS OWN WAY. *Like some bejeweled witch from the nether world,* Thaumalampas diadema *is a gaudy creature as it glides through the depths, flashing its ruby-red, sky-blue, and mother-of-pearl light organs. Some of the illumination glows through the transparent flesh of the pouch; other lights surround the eyes with which the squid detects its prey.* (Valdivia Reports, *1926*)

shapes of deep water fishes result sometimes from distended stomachs, for meals are few and far between, and the diner must accommodate itself to whatever food chances to come along.

Squids are not the only creatures decorated with light-producing organs; fishes also get lit up. In some fishes, these organs form rows, similar to the lighted cabins of ocean liners; in others they are arranged in fantastic patterns, each characteristic of a species. Far below the surface waters, with their sharks, dolphins and flying fishes, live the illuminated hatchet fishes, lantern fishes, and the ubiquitous *Cyclothone*.

How the Lights Work

What is the purpose of this built-in illumination of deep sea life, and how does it work? In a lightless world it not only serves to frighten enemies, to lure prey, and to attract the other sex, but it also is the only source of visual information. Abyssal light organs vary widely in their degree of development, but are always modifications of skin glands. Some are simple pits or pockets, but others may be highly complex, with reflectors and lenses, like the running lights of a ship. Sometimes the glands secrete their own light-producing materials; in others they act as pockets in which light-producing bacteria find a home.

In all cases oxygen is necessary for the production of light, so that through nervous control of the blood supply to these organs the fish may flash his lights on or off at will. Sometimes the light organ may be moved by special muscles, and thus be directed in the manner of a searchlight. There are even light organs with a muscular diaphragm whereby the light may be increased or reduced.

The Uncanny Angler!

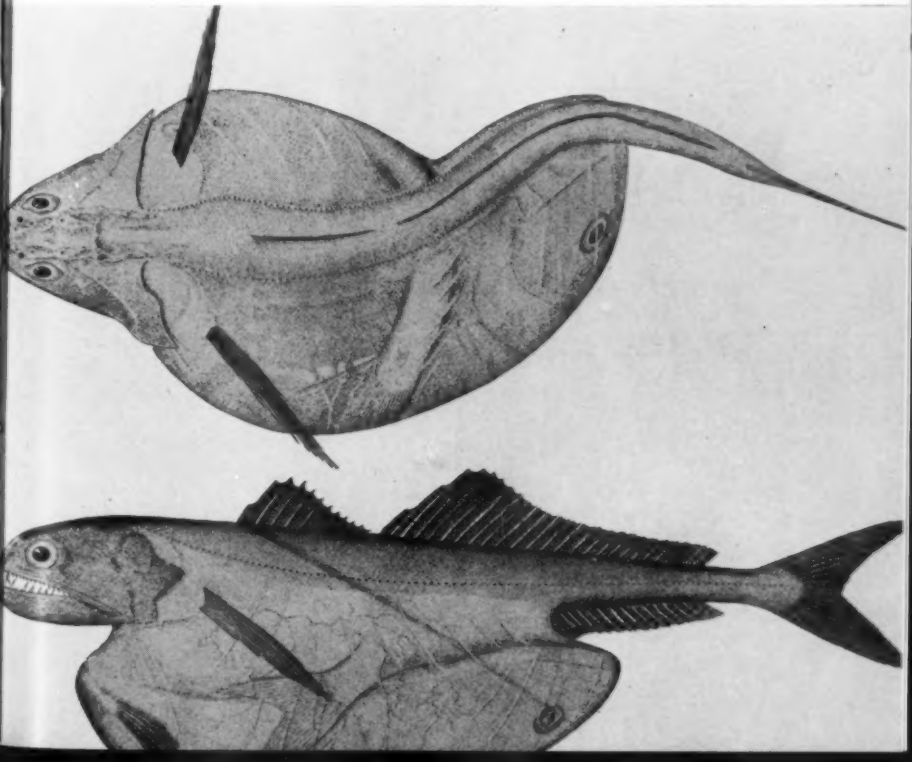
Use of living light for aggressive purposes reaches its acme in the bizarre deep sea angler fishes. These have attained a degree of certainty in the catching of other fishes which would put a human angler to shame!

The first ray of their dorsal fins arises from just behind the upper lip of the mouth, and is modified in such a way that it bears a remarkable resemblance to a rod and line. In at least one genus of this group, the rod is long and jointed, and the free end actually possesses a hook. Near the tip there is also a fleshy lobe well supplied with luminous organs of varying size.

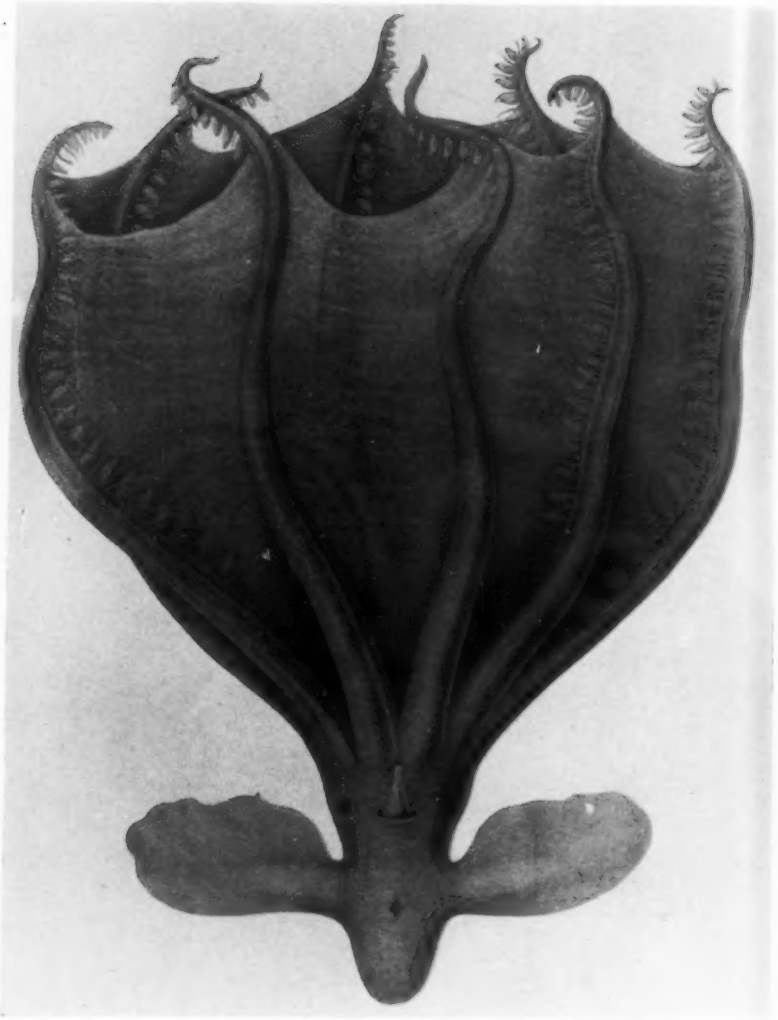
No Escape

These odd fishes owe their monstrous appearance partly to the enormous development of the head and the mouth, which is provided with huge teeth. The head takes up more than a third of the total length of the fish, thus making it nearly as broad as it is long, and giving the creature a squat ungainly appearance.

Apparently these extraordinary features are related not only to the angler fish's feeding habits but the absence of sunlight as well. Sluggish and lacking in muscular power, the angler fish moves slowly through the black water with its luminous lure extended ahead. Occasional small prey are attracted by the lure until close to the mouth of the angler. Suddenly, the huge mouth, bristling with



WHEN MEALS ARE FEW AND FAR BETWEEN, *it is good to be able to handle one sufficiently large to last a long time. This is how a deep sea fish called the crosstoothed perch,* Chiasmodus niger, *looked after consuming a fish larger than itself. Its very extensible stomach is viewed from above and from the side.* (Oceanic Ichthyology, *1895*)



NOT EVEN MADAME POMPADOUR'S HAIRDO *could match the elegance of this strange squid's membrane-connected tentacles. Most deep sea creatures have well developed eyes to cope with the dim light, but* Cirrothauma murrayi *is almost blind, perhaps because it lives close to the North Atlantic sea floor, in nearly 10,000 feet of water. It depends upon its light organs to lure prey within the folds of its upper body. Though weird to look at, this grotesque creature is gelatinous and fragile.* (Valdivia Reports, *1926*)

teeth, is opened wide and the food is snapped in. The obvious principle is that, where food is scarce, no possible chance of escape must be given the prey.

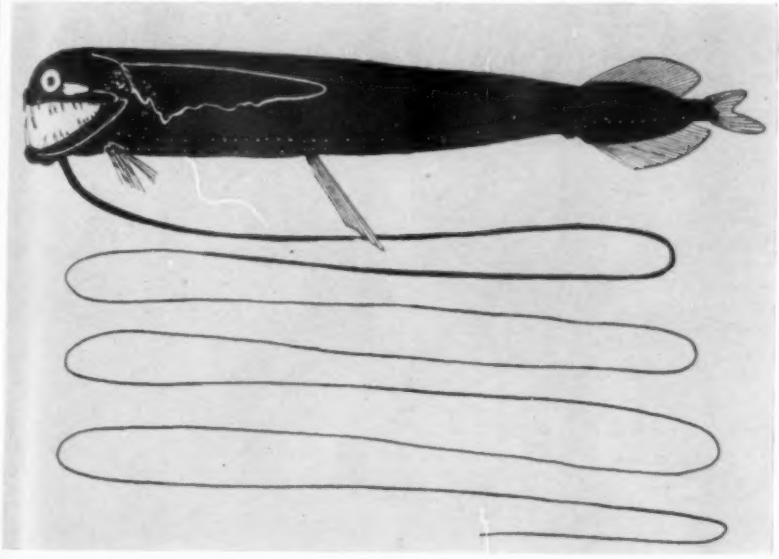
While all deep sea anglers are grotesquely misshapen, mainly as a result of the enlarged head and mouth, the variation in appearance is considerable. One of them, *Gigantactis macronema,* found at the 15,000-foot depth in the Atlantic, has a fishing rod which is thin and filamentous, and many times the length of the body of the fish. *Caulophryne acinosa,* found at half this depth, has extremely long spines growing from the hinder end of the body to form a huge fan, several times the size of the fish.

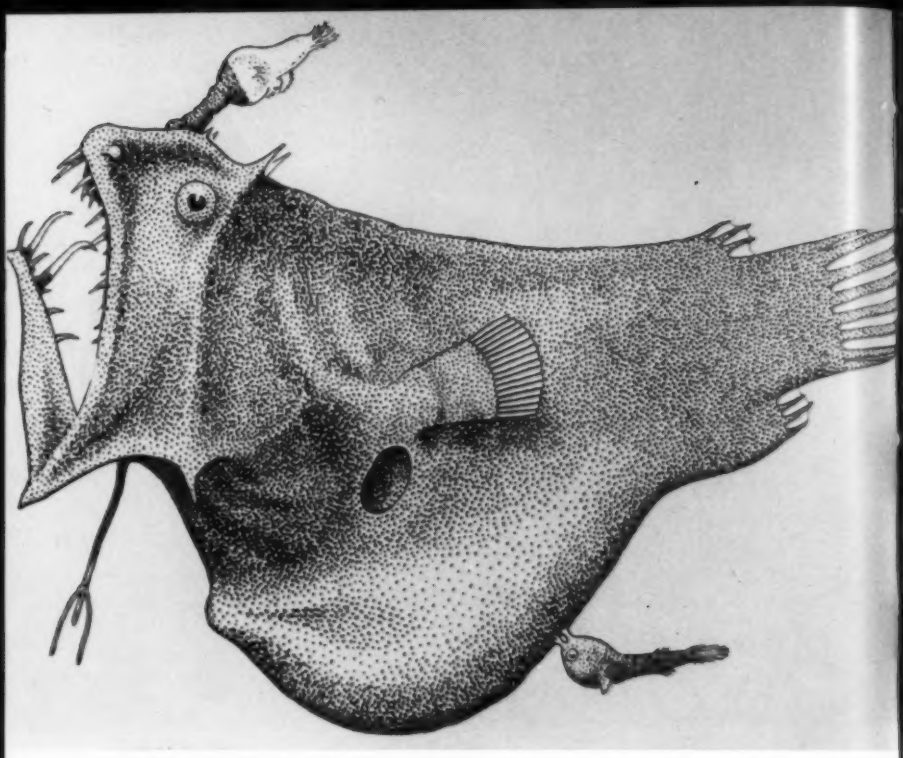
Hideous Sight

In some of these strange creatures the luminous bait is short and stubby, sometimes branching into a tree-like growth. In others a long-branched filament grows downward like the remnant of a beard. Nearly all of the deep sea anglers have rough, thorny or knobby skin, which adds to their hideous appearance. Yet very few reach a length of three feet, and most of them are six inches or less.

The vast spaces of the deep and the comparative scarcity of life within

FROM ITS LOWER JAW, Grammatostomias flagel'ibarba *trails a barbel that is even longer than its name. In some cases this odd appendage is ten times the length of the fish—one of a group known as melanostomiatids. The white dots along its lower sides are luminous organs that the fish lights at will. Scientists are not certain about the functions of the long, trailing barbel, but it may be sensory in nature, possibly helping to detect the presence of prey.* (Zoologica, *1939*)





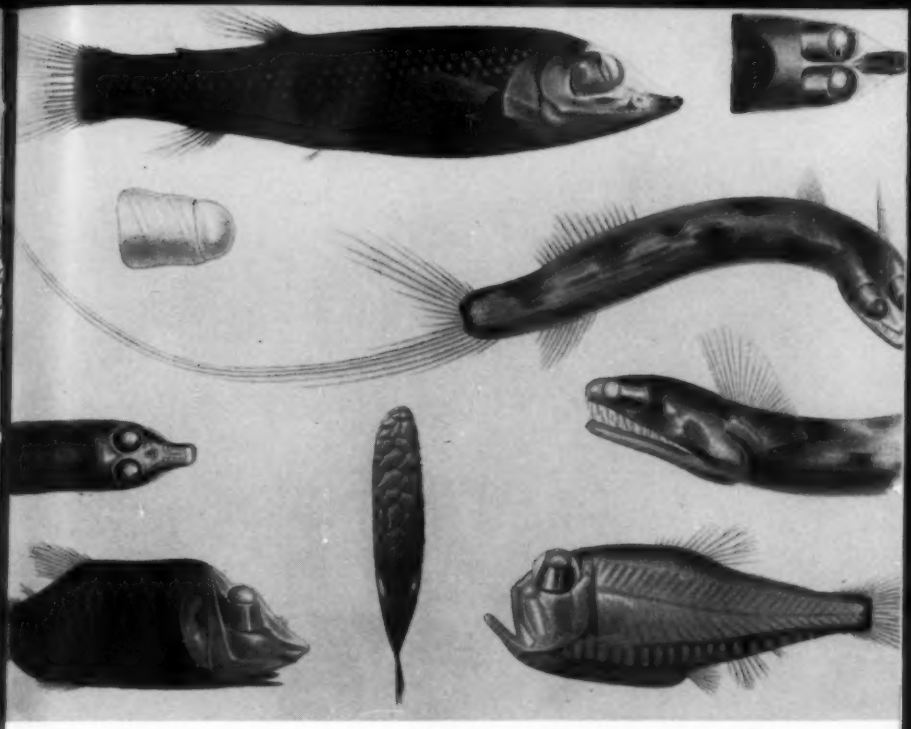
LITTLE MONSTER AND DWARF MATE. *Deep in the Indian Ocean dwells this pair of horrors—the female* Linophryne argyresca *to which is permanently attached (lower right) a tiny parasitic male. The first ray of the female's dorsal fin grows into a stalk bearing a lantern or luminous lure, like the bait on a fishing line, characteristic of the devilfishes or deep sea angler fishes.* (Dana Reports, *1932*)

it lead to other problems which are reflected in the strange appearance and habits of these fishes. Under such murky conditions the chance meeting of mature males and females of a given species is considerably less than in the more densely-populated surface waters. For fishes that swim actively or keep together in shoals, mating is not too great a problem. But for the slow-moving solitary types that must lie in wait for prey or mate, the situation may seriously threaten their ability to propagate the race. Some of them have overcome this by an almost incredible adaptation.

Joined for Life

Early collectors of these fishes were puzzled by the fact that only females were caught. Later it was discovered that the males are quite different in appearance from the females. In fact, some of the males, when first discovered, were believed to belong to an entirely different species. But the most remarkable thing was that what were believed to be parasites on the skin of the females were actually the tiny but adult males.

When the male, earlier in life,



GREMLINS OF THE INDIAN OCEAN. *Most remarkable feature of these strange fishes is their telescopic eyes with lenses at the end. While not optically "telescopic," these tubular organs give stereoscopic vision and depth perception. Ordinary fishes lack this because their eyes are on the sides of their heads, and thus cannot look in the same direction. In the inky blackness of the deep sea, upward-pointed tubular eyes may detect specks of light which mark light organs alongside the undersides of their prey or enemies. Shown here are (top)* Winteria telescopa, *about five inches long; (middle)* Gigantura chuni, *eight inches; (bottom left)* Opisthoproctus soleatus *two inches; and (bottom right)* Argyropelecus, *three inches.* (Aus den Tiefen des Weltmeeres, *1903*)

meets a female, it attaches itself to her body. Its jaw and tongue then grow into the tissues of the female, and their blood streams become united. In this way the male digestive organs may degenerate and it remains as a parasitic dwarf, with its functions reduced to fertilizing the eggs.

The male of these fishes is thus quite unlike the female, and its dorsal spire or lure is transformed into a kind of large nose, bearing a tooth. This is the device which enables it to become attached to the female.

Source of Scattering Layer?

The problems of living in the deep are solved in various ways by other fishes. Lantern fishes, for instance, have two rows of lights on their undersurface, with additional ones on the heads and sides, arranged in the pattern of its species. As in many of these fishes, their eyes are relatively huge. A puzzling feature of the lantern fishes is their habit of migrating

SHRIMP FEAST, FATHOMS DOWN! *A school of gleaming-tailed sea dragons* (Idiacanthus fasciola) *pursues crustacea in the Atlantic depths off Bermuda, ready to engulf them in vicious jaws. Light organs glow along their sides like the portholes of an ocean liner.* (Zoologica, *1934*)

towards the surface at night and back to the depths in daytime. It is possible that swarms of these creatures account for the "scattering layer," the mysterious false bottom or echo appearing on the echo sounder chart, which moves upwards at night.

At this point let us take a look also at the hatchet fishes. Although they possess large light organs, they differ from the lantern fishes in their grotesque flattened profile, and silvery iridescent bodies.

In spite of their forbidding appear-

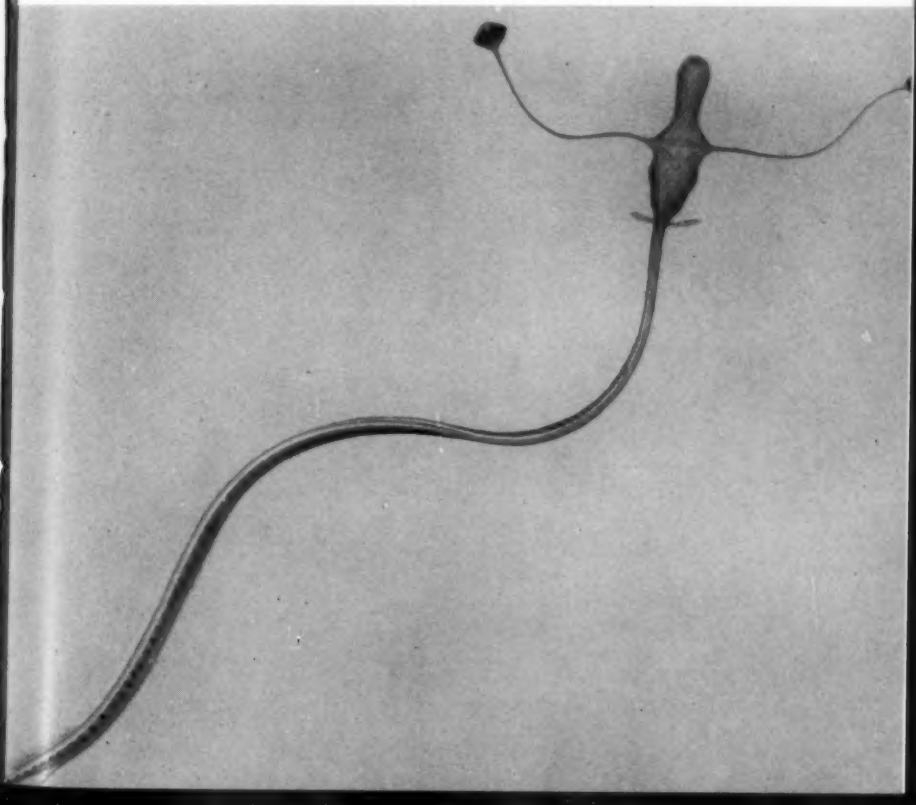
ance, they rarely exceed three inches in length.

Prey Larger than Catcher

Some deep sea fish actually have a mouth hinged in such a way that it can be extended and engulf prey as large as or even larger than itself. Several of the dragon fishes, for instance, have long thin bodies but highly efficient mouths with teeth of amazing length. The lower jaw is arranged so that it can be thrust suddenly forward to trap the prey, which is raked into the cavernous mouth with a snapping action.

The bodies of the dragon fishes or stomiatoids are usually black and illuminated with rows of light organs, and many of them have long luminous barbels, like antenna, growing beneath the mouth. In one case, *Grammatostomias flagellibarba,* the barbel is six times the length of the fish, and seems not only to attract prey but also to be a highly-sensitive organ for detecting the presence of food or larger enemies.

The most uncanny of these nether



STALKED EYES ARE FOUND *in the young of a number of deep sea fishes, but never in adults. The stalks, whose purpose is unknown, shrink as the fish grows older. About an inch long, this grotesque* Stylopthalmus paradoxus *was captured in a vertical net haul from the equatorial region of the Indian Ocean, more than 5,000 feet deep.* (Valdivia Reports, *1909-1914*)

FLESH EATING PLANT? *This is really an animal! Stalks of the sea lily* (Metacrinus nobilis) *grow up from the sea bottom to a length of several feet. The mouth lurks in the middle of the crown of "petals" or tentacles. Related to the starfishes and sea urchins, whole forests of sea lilies carpet the sea floor in some places.* (Valdivia Reports, *1925*)

world creatures perhaps are the gulpers or pelican eels. Although they grow to be about five feet long, practically all of this length consists of a thin tail. At the other end a colossal mouth opens like a sac. At first sight the mouth would seem to be needlessly large, since the stomach is so much smaller. But when this wandering trap engulfs its prey, the stomach and body miraculously distend until the prey, larger than the gulper, can be plainly seen through the thinly stretched wall of the body.

One of the deep sea perches, *Chiasmodus,* has a stomach with sufficient capacity to engulf a prey more than twice its length. Its capacity is really prodigious, even though only about four inches in length.

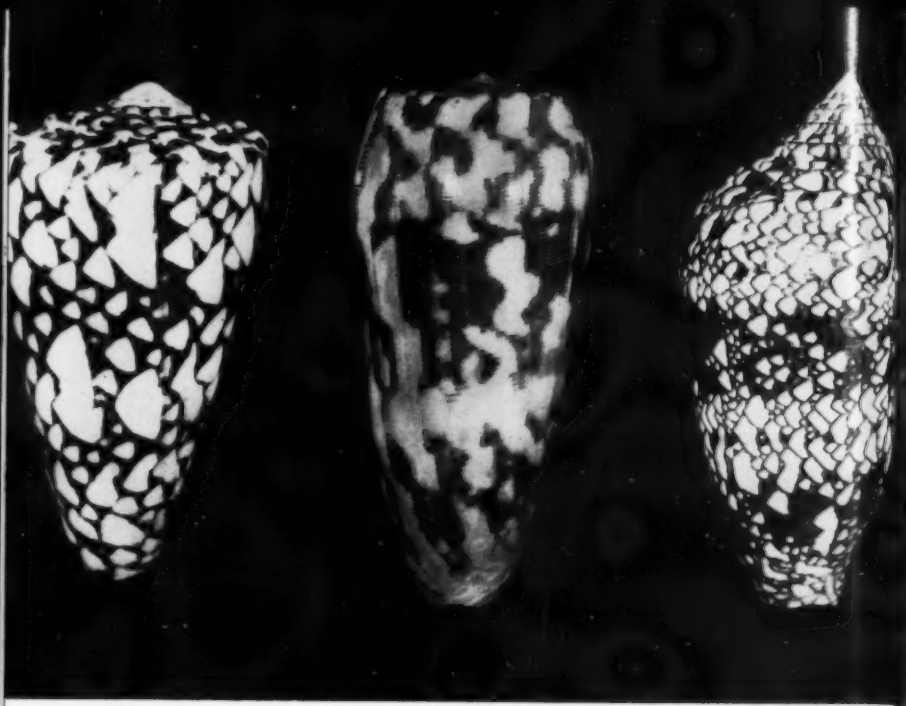
Although life is sparse and widely scattered in deep waters, the number of strange types is great. There are fishes, such as the giant tails, which have the lower tail lobe longer than the rest of the body, apparently a useless adornment. Others, no doubt in response to their dark surroundings, have no eyes and are completely blind. On the other hand, many have extra large eyes supported on moveable stalks, which enable them to use the faint light produced by the fishes themselves.

The young or larval stages of many deep sea fishes show the greatest extravagance. An excellent example is that of a trap-mouthed (stomiatoid) fish known as *Idiacanthus fasciola.* When the larval fish is little more than half an inch long, it is about as thick as a pin or needle. But its eyes are thrust out from the body on thin moveable stalks which are almost half the length of the fish! Before the little creature has reached a length of two inches, however, these tubular eyes have degenerated and the fish resembles the adult in appearance.

Yet other fishes retain short tubular eyes during their entire life. Possibly these enable the possessor to localize by improved depth perception the small points of luminescence which represent other fishes.

At the bottom of the deep sea the marine biologist finds other strange animals, such as one having the appearance of large grey flowers with stalks as much as five feet high. These are the crinoids, relatives of the sea urchins and starfishes and referred to sometimes as sea lilies. In mid waters, fast moving shrimp eject luminous substances, forming a glowing haze, in which they escape the viper fish which prey on them.

In fact, these abyssal hosts of unearthy creatures for sheer monstrosity put to shame the weirdest of man's imaginings. Tubular-eyed, trap-mouthed, rubber-stomached animals of the deep seas, prowling in a world of faint pinpoint lights produced by their own activity, are found in all the oceans, but few persons have seen or ever will see them.



BEAUTIFUL BUT DEADLY! *When alive, the dwellers within these Pacific cone shells can inflict a dangerous and sometimes fatal wound if carelessly handled. The marbled cone,* Conus marmoreus, *(left) feeds on other cone shells.* Conus striatus *(center) feeds exclusively on fishes, while* Conus textile *feeds on other snails. (Photo from author)*

Original Spear-Fisher

By SHIRLEY M. TREFZ

THERE IS A SNAIL which actually catches live fish! How, you may well ask, can such a relatively sluggish creature capture and eat anything as alert as a fish? Yet fishes apparently are the exclusive food of certain tropical marine snails which belong to the cone shell family. Even more curious, these snails capture their prey by spear-fishing!

The cone shells are among the handsomest animals in the sea. Their striking patterns and varied colors have long been the delight of shell collectors. Live specimens must be handled with great care, however, because these apparently harmless snails can strike like angry snakes. Furthermore, they inflict a small but possibly mortal wound by means of a tiny dart and a virulent poison. Several instances in which cone snails have caused death are recorded in scientific and medical literature.

A cone shell has within its gullet a bundle of murderous barbed darts which it uses, one at a time, to stab and poison its prey. These hollow shafts are actually specialized teeth, made of a stiff, glassy material, and resemble a harpoon with hollow shaft and one or more prominent recessed barbs.

The upper end of these darts is supplied with a paralyzing venom from a large poison gland. When the victim, be it a worm, a fish, or another snail, is "speared," the poison affects the nervous system, causing paralysis and death, often within but a few seconds.

Observed in Aquarium

At the Hawaii Marine Laboratory, in Honolulu, Dr. Alan J. Kohn and colleagues actually observed one of the spear-fishing cones in action in an aquarium. The snail studied was the striated cone *(Conus striatus)*, the name being derived from the fine parallel lines or striae marking the shell. This species apparently subsists on fishes, because examination of the digestive tracts of several specimens revealed the presence of fish bones and scales.

The snail was placed in an aquarium with several inches of sand on the bottom. It immediately buried itself in the sand. However, the animal allowed its siphon to extend above the sand.

Tubular Nose

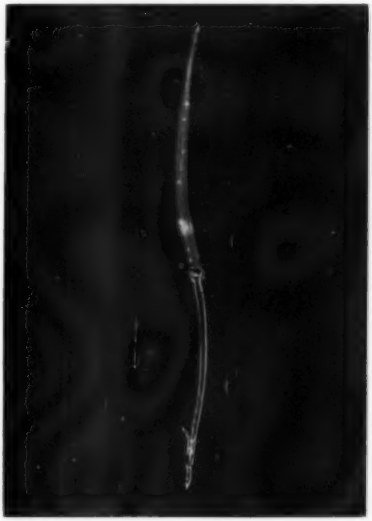
This siphon is a kind of "sniffing" organ. It directs a stream of water into the snail's body and over a sensory structure which enables the snail to taste or smell the surrounding water. By this means, rather than by the sense of sight, the snail detects the presence of a nearby fish.

As soon as a fish was placed in the aquarium, the snail became active. It pushed itself up out of the sand, and extended its long tube-like snout or proboscis. The tip of the proboscis moved back and forth, following the swimming movements of the fish. Within the proboscis the snail held the beautifully designed and formidable dart.

Quickly Attacks

When the tip of the proboscis touched the fish, the dart was thrust into the fish with considerable force and lightning speed. The harpooned

POISON DART FROM THE FISH-SPEARING *striated cone shell. This enlarged view shows the barbed tip of the weapon. The dart is hollow, about 5/16 of an inch long, and contains the paralyzing poison. (Photo from author)*



HERE IS WHAT LURKS *behind beauty of the spear-fishing cone shell. The poison sac (A) is linked by the poison duct and gland (B) with the radula sheath (C), which contains the bundle of darts seen to the right. Each dart is used just once, and then a new one replaces it in the proboscis. (Photo from author)*

fish writhed and flipped for a few seconds, and finally ceased its struggle as the venom took effect. The snail, meanwhile, opened its cavernous mouth, and the proboscis, holding tightly to the upper end of the dart, drew the impaled fish into the cavity.

A striated cone can eat a fish equal in length to its own shell, but the snail must digest the fish before its body can withdraw into the shell again. This process requires several hours following a meal. The poisonous dart, oddly enough, is taken into the digestive tract along with the victim, and a new one from the bundle of spares takes its place in the proboscis.

Cone shells are not a menace to the average swimmer, though cones have been responsible for the death of a number of humans, because they are usually at least partially buried in sand or hidden under rocks. However, shell collectors and skin divers should be aware of the potential menace in some of them. Although several species of this family are small, and perhaps do not have enough poison to kill a man, others are dangerous.

If they must be handled, it is best to hold the snails by the broad back end of their shells, with the narrow "business end" directed away from the hand. It should be remembered that the animal is capable of extending its body well beyond the opening of the shell, and, if the probiscis is extended, do not try to pick it up.

Birds or Fish?—Peru's Dilemma

By C. P. IDYLL
Chairman, Gulf & Caribbean Fisheries Institute

BIRD DROPPINGS or fish meal? Peru may soon have to decide between these strange alternatives. Is the centuries-old guano industry being endangered by the new-born fishery for anchovetas (fish which are reduced to fish meal and other products) and, if so, is this detrimental to the economy of the country?

The conflict arises because guano is the dung of sea birds. The birds feed almost exclusively on the same anchovetas that provide raw material for the fish meal. The question plaguing Peruvians is whether the fishermen take enough food from the mouths of the birds to reduce their numbers, and therefore the production of guano. If the reply be affirmative, another question arises: Is this loss in guano offset by the value of the fish meal produced?

Some Term it "Disaster"

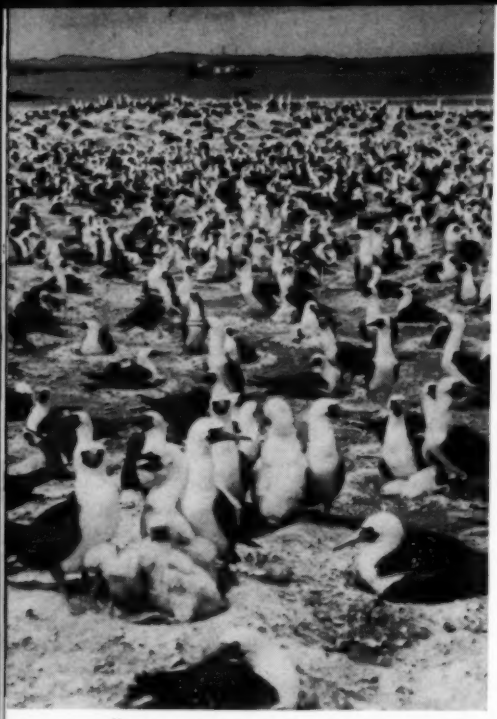
These are difficult questions. To answer them requires more knowledge of the life histories of the several species of birds and fishes involved, particularly the way their populations are changed by predators, including fishermen. Also involved are complicated economics: the relative values and markets for the two types of products, both now and in the future. Some scientific observers have already implied strongly that the new commercial fishery is a disaster, threatening the future of a profitable guano industry without much promise of a worthwhile substitute.

Peru's guano industry has an ancient, if odorous, history. Pre-Columbian Indians used bird manure as fertilizer. They recognized it as a renewable resource, and the early Spanish chronicler Garcilaso de la Vega gives an interesting account of their measures for the conservation of guano. Thus from the time we have records, Peru has exploited these deposits.

Guano Paid for Railroads

This use gained momentum with the rising industrial pace of the nineteenth century, and the Castilla Administration used the proceeds from increased guano exports to finance an expanded program of industrial and economic development in the 1850's. Guano paid for vast programs of public works, including railroads joining the hitherto almost isolated parts of the mountainous country. Improved communications led to prosperity in other areas, especially agriculture.

This strange source of wealth seemed to the Peruvians to be there for the taking, and the usual pattern of exploitation followed. Enormous deposits of guano, which had required centuries to produce, were greedily attacked. Some beds were at least 150 feet thick and since it takes about a century to build up six feet of guano, these enormous old deposits must



SECOND MOST IMPORTANT *guano producer is the Peruvian booby or piquero* (Sula varigata), *which has a white head and body, and brown-speckled wings. Its Spanish name means "pikeman," and refers to the arrow-straight plunge this bird makes into the water in pursuit of its prey. (Compañía Administradora del Guano)*

have required some 2,500 years to make. In the twenty-five years from 1850, Peru exported twenty million tons of guano, worth $2 billion.

More Valuable than Gold

As ancient deposits melted away under this heavy onslaught, conservation measures became necessary if the harvest were to continue. In 1909 the *Compañía Administradora del Guano* was created, and its studies and regulations slowed the feverish exploitation to a more rational pace. By careful management, annual yields rose again, and enough harvesting is possible now to make guano more valuable to Peru than gold—the glittering prize that the Conquistadores sought so bloodily.

The occurrence of large quantities of guano in Peru, and in the northern part of Chile, is not only due to the presence of huge schools of small fish that supply food for the manure-producing birds, but also to an extremely dry climate, with no rain to wash away the guano deposits or dissolve out their nitrates and other valuable chemicals.

Chief Guano Producer

Several kinds of birds produce guano, but two of them are considerably more important than the others and one in particular is dominant. The latter is the guanaye, or Peruvian cormorant, *Phalacocorax bougainvillii*. This bird is similar to the fishing cormorant of the Chinese. By placing a ring around its neck to prevent the cormorant from swallowing the catch, the owner is able to train it to fish for him.

The guanaye has no such impediment, however, and is able to swallow enormous quantities of fish. The crop and gullet of one dead bird yielded the remains of seventy-six anchovies, each four to five inches long. The populations of the three Chincha islands, one small portion of the guana-producing area, are reputed to consume 400 to 500 million pounds of fish per year. The total consumption has been estimated to be three million tons a year.

Guanayes are big birds, standing some twenty inches tall, with dark green back feathers and white breasts. Their eyes are ringed with red and green naked skin, giving them a dour expression.

The second most important guano bird is the Peruvian booby, or piquero, *Sula varigata*. The Spanish name means pikeman, and refers to the arrow-straight plunge this bird makes into the water in pursuit of its prey. It has a white head and body, and brown-speckled wings.

No Count; Just "Measure"

Literally millions of guanayes and piqueros nest on the bare rocky islands off the coasts of Peru. On Macabi Island alone, for example, a million birds have been estimated to reside. They are so thick that the government wardens, in making a census, do not try to count, but rather "measure" them, figuring three families to the square yard.

Each guanaye family produces a clutch of three eggs, in a nest of guano lined with feathers. Guano is the only substance on these barren rocks to make a nesting place for the eggs. The female shapes the dung into a bowl-shaped depression, and the islands are pitted with enormous numbers of these strange nests.

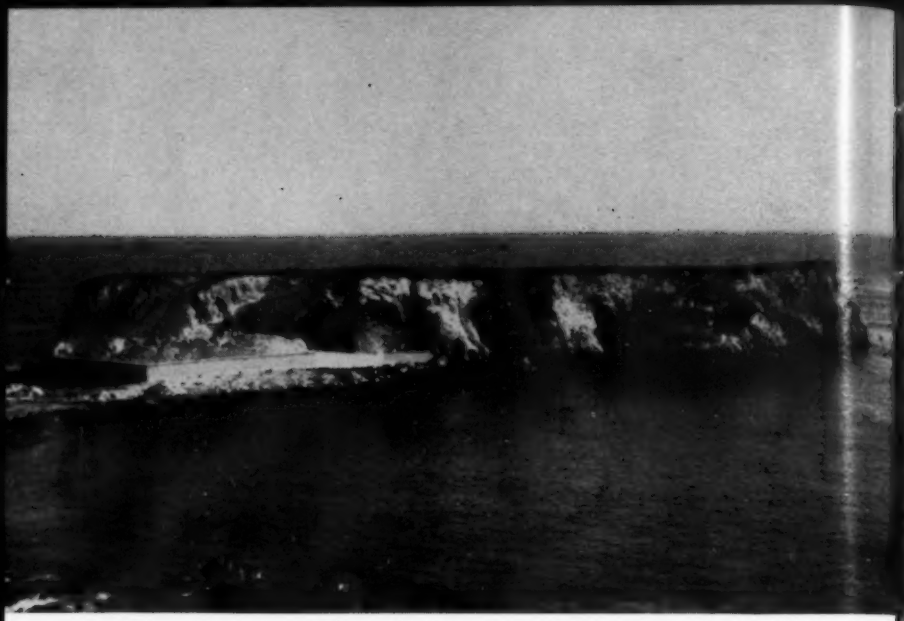
Limiting Factor—Nesting Space

In a healthy population of birds, the limiting factor seems to be nesting space. Population increases have been artificially induced by building platforms to span closely adjacent islands. Recently, nesting groups have been established on jutting points of the mainland, by building walls to keep off marauding cats, rats and zorros, or wild foxes.

RED-RINGED EYES *give the guanaye, or Peruvian cormorant, a "hang-over" expression, but he is the king of the guano world. This most important of the fertilizer producers is a big bird, standing some twenty inches tall, and eats enormous quantities of fish. The total consumption of fish in Peruvian waters by all guano birds is estimated at three million tons a year. (Compañía Administradora del Guano)*

Humboldt Current

The birds do not always remain healthy, and like all animal populations, the guanayes have their ups and downs. These are associated with the cycles of fish abundance, and there appear to be seven-year cycles in the anchoveta populations.



STONE WALLS ACROSS *the neck of a rocky peninsula safeguard sea birds from predatory animals—cats, rats, and zorros, or wild foxes—from the mainland. In effect, the barrier makes an island of the headland, providing additional needed space for nesting, which the birds have been quick to accept. (Compañía Administradora del Guano)*

The most dramatic changes in the abundance of fish, and hence of birds, takes place as a result of oceanographic changes in the rich waters, which therefore deserve some attention. The principal feature of the coastal waters off Peru is the northward-flowing current of cold water, called the Humboldt Current. This is a big mass of water, roughly a hundred miles wide at its southern edge and over a thousand miles wide in the north.

Humboldt's richness was formerly thought to be the result of the transport of nutrient materials from the Antarctic regions. Baron von Humboldt, the Prussian for whom the current is named, held this view as a result of studies he made in 1803.

The modern oceanographer has discarded this idea. It is now believed that the fertility results from upwelling, which takes place when the surface waters are driven westward away from the coast of South America by the prevailing southeasterly winds. To replace this water, masses of cold water from the deep areas of the ocean arise. These deep waters are rich in nutrient salts, derived from bodies of dead plant and animal material, which rain slowly and continuously from above. Below the sunlit upper waters plants cannot live so that the fertilizer salts are able to accumulate until brought back into the living cycle by the upwellings.

In this way, the upwelling current sets in motion an immense new wheel

of life. The microscopic plants in the upper layers transform the nitrates and phosphates and other chemical materials into living protoplasm. These are eaten by tiny plankton animals, which in turn are consumed by small fishes, and so on up the chain to birds and finally man himself.

When Nature has a Fling

When the current patterns off Peru behave, all goes well with the fish and the birds. But nature has a way of upsetting the *status quo,* and every few years she has a fling, changing things around rather like a housewife altering the arrangement of the furniture in the living room. The Humboldt Current is moved offshore on these occasions, and a countercurrent from the north wedges into the area between the coast and the displaced Humboldt Current.

The countercurrent is warmer than the normal current and less endowed with nutrients, and thus is disastrous to the marine life of the area, which is atuned to a chilly environment and rich fodder.

The warm countercurrent from the north usually comes around Christmas time, and has thus been given the name El Niño, The Child. Since the normal planktonic food of the anchovetas is missing, and because the water is warmer than they like, the fish leave their normal habitat. The guano birds starve at such times, and appear to go mad, leaving the area in great flights. In some years their bodies litter the beaches in great windrows. Infection may be as much a factor in this mortality as starvation, but in either case the results are serious for the guano industry.

On some occasions another phenomenon accompanies El Niño. This is the "Callao Painter," so termed because it turns the white paint of ships dark (especially in the harbor of Callao), a result of the production of hydrogen sulphide in the water from decomposing fish and other marine creatures. The sea may also be turned yellow, red or brown.

El Niño and The Painter wreak havoc with the commercial fishing industry too, of course, and while this industry is not as old in its present form as the guano industry, it is nonetheless a valuable asset of the country.

Fish Meal and Lipstick!

The newest and biggest commercial fishery in Peru is for the anchovetas, *Engraulis ringens,* the same fish that form the chief food of the birds. Humans do not share the birds' enthusiasm for anchovetas as food, but these little fishes are the basis of a promising reduction industry. Caught by purse seine vessels, they are cooked and dried and ground up into fish meal. This is an extremely valuable commodity, having an excellent market throughout the world as a high nutrient supplement to poultry and hog feed.

Oil is also recovered from the bodies of the fish, and this too has a good market for many purposes, including the manufacture of paints, linoleum, lipstick and a host of other products. A third product is "condensed fish solubles," being the liquid residue, with certain materials held in solution, which remains after the manufacture of the meal oil. The solubles also have

a market, as fertilizer and for other uses.

Startling Growth

The meal industry takes fish in large quantities and it is this volume that alarms observers, who fear that there may not be enough fish left for the birds. Some idea of the upsurge of the fish meal industry can be obtained from the landing figures. In 1948 Peru reported about 1,000 metric tons of sardines and anchovetas were landed. This may not have represented the whole catch, but even if considerable allowance is made, the increase in the next few years is startling.

By 1953 nearly 45,000 metric tons

WHILE NOT NEW, FISHING *is becoming an increasingly important industry in Peru. These are food fishermen, but also many boats are now purse-seining for anchovetas, the same fish that forms the basic food of the guano birds. Peruvian economists are wondering which will net the most—fish or guano. Also conservationists are asking whether expanded fishing may not eventually deplete the supply of food for guano birds, and impede or ruin a rich fertilizer industry. (Compañía Administradora del Guano)*

of these fish were landed. In 1956 the tal was over 138,000 metric tons, id the fishery is still expanding. Exports of fish meal in the first nine months of 1958 were 34.7% higher than they were in the same period in 1957, and the new records are reported continuously.

Hungry Birds

It is obviously impossible to make accurate estimates of the amounts of fish caught by the birds, but some guesses, attempted by scientific observers, at least indicate the general magnitude. Dr. Robert Cushman Murphy, the eminent ornithologist, who has been studying the guano birds since 1919, and whose books *Bird Islands of Peru* and *Oceanic Birds of South America* are classic authorities on the subject, estimates that there are tens of millions of birds which eat three million tons of fish a year. Others, such as Dr. Popovici, now working in Peru, estimate the number of birds to be from twenty-five to fifty million.

Catching Up with the Birds?

Now compare this voracity with the catches of the purse seine boats. As mentioned earlier, the total Peruvian catch in 1956 of herring, pilchards and anchovetas combined was 138,500 metric tons, or about 152,700 short tons. On this basis the birds took not less than twenty times as much fish as the commercial fishery in 1957. Other estimates make the ratio much higher. Even at its present rate of increase, it will be a long time before the fishery catches up to the guanayes.

But suppose that eventually the fishery does catch up, and suppose that the fish population is not able to supply both the birds and the fishermen, is this necessarily bad? Not if the resulting product, fish meal, is of more value to the country than guano, the product it displaces.

How much guano is produced by the birds? In *La Economia del Mar* Popovici says that a guanaye bird ingests about sixteen tons of fish to produce one ton of guano. Hutchinson, in his study of animal excretion, calculates the figure to be lower, figuring that for an annual production of 150,000 tons of guano the birds need to eat 1,640,000 tons of fish—some 10% of the total world production of fish in 1947.

Not All Recovered

The next point to be considered is that not all the guano produced can be recovered. Murphy says "A relatively small proportion of guano is deposited on the islets, where it becomes available for human use; the remainder returns to the sea—." Popovici supposes that "for each ton deposited on the land, another ton of material is returned to the sea—by the birds in their flight."

In addition, not all of the fraction which finds its way to the land is recovered. Murphy describes guanayes, having fouled their plumage with fresh guano, flying to the water to wash themselves. Some guano is, of course, lost in the harvesting and by other means.

Let us take the conservative view, however, ignore these latter factors

MODERN CONCRETE DORMITORIES are *gradually replacing the wooden barracks housing guano workers during the time they live in these desolate offshore islands and arid peninsulas along the coast of Peru. (Compañía Administradora del Guano)*

and accept Hutchinson's figure for fish-guano conversion, and Popovici's for the proportion of guano lost. This provides us with the estimate that it takes some twenty-two tons of anchovetas to provide one ton of usable guano.

One to Five Yield in Meal

The figure for the yield of fish meal from raw fish is a good deal easier to obtain and is more accurate, namely that one ton of fish produces 400 pounds of meal, a one to five ratio. These figures are for menhaden, but they should be similar for anchovetas. What will be lower in the case of anchovetas, however, is the oil yield. Menhaden produces from three to six times as much oil, depending on the exact kind of fish and on the season.

We now have the comparative figures of yield of guano and of fish meal from the same raw material, the anchovies. About ninety-one pounds of dry guano are produced from a ton of fish and 400 pounds of fish meal from the same quantity of raw material. The reduction process will also yield some oil and if we accept the figure of one fifth the oil yield from anchovetas compared with menhaden we should get about fifty-six pounds of oil from a ton of the former species.

And Now Prices . . .

Finally, the matter of price is to be considered. In January 1959, fish meal was bringing about $125 per short ton, f.o.b. Callao. The price of guano in 1959 has been about $73 per short ton. The fish oil price in 1959 in Peru is about $107 per short ton.

Putting yields and prices together, we find that 100 tons of raw fish would give some 9,100 pounds of guano worth $332. The same quantity of fish would give about 40,000 pounds of meal worth about $2500 and approximately 5600 pounds of oil worth about $300, a total of $2800 worth of fisherman-produced materials, ignoring the condensed fish solubles that would raise this total.

It should be remembered that these calculations have given every advantage to the birds. Hence the advantage of over eight to one in favor of catching anchovetas to produce fish meal, instead of allowing the birds to convert it to guano, is undoubtedly a minimum, and the ratio may very well be ten to one or perhaps much higher.

In the face of this it is puzzling to read statements such as the following: "There is official concern over the increasing drain on anchovy resources as a source of fish meal. It is feared that the guano industry will be damaged as the large flocks of sea birds *(aves guaneras)* are dependant on the anchovy as a source of food" and "In a decree dated December 1, 1956, and effective January 1, 1957, no new authorizations will be granted in Peru for the establishment of fish meal plants or the enlargement of existing plants that use anchovies for reduction."

The fish meal industry, straining to expand under the stimulus of a strong market demand, is being dis-

PROCESSING GUANO. *Before it is shipped to world markets as fertilizer, guano is treated in big covered sheds, where it is mixed, aerated, and "homogenized" to assure an even-textured product. Laboratory tests determine the best use of various batches for different types of soils and agricultural purposes. (Compañía Administradora del Guano)*

BACK-BREAKING WORK *in the torrid tropical sun has been the hard lot of the guano worker, using pick-and-shovel to scale off the layers of fertilizer deposited by countless sea birds. However, mechanized equipment is now being installed where it can be transported to the clifftop locations on which most of the birds build their nests. (Pan American Union)*

couraged from doing so. It appears from economic considerations that this is unjustified.

It is, of course, not hard to understand the reluctance of Peru to do anything to damage a part of its economy so anciently based as the guano industry, and it is likely that this accounts for much of the present official attitude. The other principal reason, in all likelihood, whether it is stated or only implied, is that, while the birds are not able to deplete the anchovy stocks, man, the most rapacious of all predators, might quickly do so.

Sea as a Limitless Provider

What are the chances of the anchoveta stocks becoming depleted, with and without commercial fishing? For a long time it was hard to believe that anything as immense as the sea, supporting schools of fish of such tremendous sizes, would not simply pour in replacements for the netfulls

taken out by the fishermen.

In the last few decades, however, it has become increasingly clear that fish stocks are limited, and that they can be depleted. This is because the ocean is not one big homogeneous mass, but has a great variety of habitats, some congenial to fish and some as desert as the Sahara. Individual sea animals become delicately adjusted to certain combinations of temperature, salinity, pressure, light and a multitude of other environmental conditions, and this combination may occur only in a restricted area.

No Natural Reserves

So, if the fish population of this area is depleted there probably will be no nearby storehouse from which to draw replacements. Rises and falls in the numbers of animal populations which are untouched by man are very familiar, and there are fewer better examples than the very stocks we are now discussing.

The seven-year cycles in anchoveta and guanaye populations have already been mentioned. This is a predator-prey relationship; it is probably set off by changes in the numbers of fish caused by changes in oceanic conditions, and there follows a decline in the numbers of the bird predators.

Greatest Predator—Man

The greatest predator of all is man, and it is clear from research done in recent years that this predation can depress fish populations—sometimes to disaster levels. The history of the great fisheries of the North Sea is most instructive in this. It has been shown with mathematical precision that fishing has been the principal factor in controlling the size of the plaice and haddock and other stocks in the North Sea. Enforced cessation of fishing during the two World Wars, for example, resulted in the recovery of the fish populations to high levels, to be followed by quick reduction of abundance when heavy fishing started again.

Pelagic Fish Hold Own

It is important to note that these sensitive reactions of fish populations to fishing pressure refer in the North Sea only to the demersal species (those which live on the bottom), like the flat fishes and the members of the cod family. Despite centuries of fishing, becoming more intensified with the passage of time, the pelagic fish (those that swim in midwater, like the herring) have held their own in a remarkable way.

BECAUSE THERE IS NO HARBOR *in any of these rocky islands, guano must be loaded into lighters and small ships by aerial tramway from the hilltop locations where the guano-producing birds build their nests. The sacked guano is then transferred to larger steamships for transportation to processing plants at Callao and other mainland ports. (Compañía Administradora del Guano)*

A BRAVE NEW WORLD FOR THE SPORTS FISHERMAN. *The beaches along the Pacific coast of Peru not only offer excellent surf casting for rooster fish, mackerel, snappers, cero, but a short distance offshore you will find such giant game fish as marlin and swordfish. These game fish have been the subject of research by Yale University and the University of Miami. (University of Miami-Lou Marron Expedition)*

This would make it appear that our anchovetas — which are pelagic — would have a better chance of withstanding fishing both by birds and by man than demersal species, and this may very well be true. Of course, there is no certainty of this, since one of the most spectacular cases of the collapse of a fishery is that for the California sardines — a pelagic fish related to the European herring.

So far, evidence is strong that the combined predation of the birds and the purse seines have not overfished the anchovy stocks, since the bird populations are still growing, being

held back only by the lack of nesting space.

It may be that the Humboldt Current will hold enough fish for both man and birds for many years of expanding fish meal *and* guano production. Then, if the time comes that the fish meal industry begins to take food out of the mouths of the birds, Peru will still be ahead economically. This second phase will last for another period — perhaps a very long one — and will end only if fishing becomes so intense that the immense anchovy stocks are actually damaged by depletion. This can happen, as it did in the case of the California sardines, where heavy fishing and a series of years of unfavorable oceanographic conditions virtually wiped out the fishery for several years.

But it has been shown that chances of thus damaging a pelagic stock is less than in the case of a demersal stock. Furthermore, the chances of Peru's fishery approaching the size of that for the California sardine seems to be very remote.

We have not taken into account the comparative costs of production of fish meal and guano, the comparative domestic needs for fertilizer or poultry feed, nor the sociological problems which may be created in allowing the rise of the fish meal industry in favor of the guano industry. It would be presumptuous to make a final judgment without knowing the weight of these factors. However, on the simple basis of dollars, the fisherman seems to score a clear victory over the birds.

Blood Typing for Whales and Fishes

Fishes, seals and whales show several blood types, just as men do. This is important to marine scientists because blood types can be used to distinguish various "populations" within a single species.

Dr. J. E. Cushing, of the University of California, at Santa Barbara, reports that salmon, sardines, herring and other commercial fish can thus be identified as belonging to one or another "ethnic group," which should help in tracing movements of fish at sea during migrations. Blood typing of fish is identical with the method used for human beings.

Dr. Cushing's research was carried out in collaboration with Dr. K. Takahashi, of Tokyo University, and Mr. K. Fujino, of the Whale Research Institute at Tokyo. The Japanese whaling industry is applying the method for the study of the social habits of whales.

A biologist accompanies the whaling fleet, drawing samples of blood from the whales that have been caught, and tests them for antigens with serum from rabbits, exactly as in human blood tests. This process may also be used for any fish which has red blood cells.

GAME FISHERMEN *are helping to solve the feast-or-famine mysteries of the waters off the western coast of South America. Here members of the University of Miami-Lou Marron Expedition conduct plankton studies with the aid of fine-meshed sea nets. The amount of life in these Pacific waters is sometimes so great that the surface of the water is churned up for miles around by fish, and the air is thick with clouds of screaming, feasting birds. At other times not a fish is to be found. (University of Miami-Lou Marron Expedition)*

Tribute To Anglers

THE BOARD OF TRUSTEES of the Foundation has announced the institution of a special Anglers Award, in the form of a gold medal, which will be presented each year to an angler who has made important contributions to the development of marine science.

The generosity of one of our members has made possible this recognition of the valuable service that saltwater anglers have rendered to science. The entire membership however, will derive satisfaction from the initiative of the Foundation in bringing to public attention the many ways in which sportsmen have aided the marine biologist and ichthyologist.

Tag and Return Tags

Probably the most frequent assistance given by the angler to research is in the tagging of fish and in returning information on their tagged catches. This type of study yields valuable information on migrations and growth rate. In some cases it may also make possible a calculation of the effects of fishing pressure and natural mortality on the fish stocks.

During the past few years, in the United States alone, tagging has provided information on a surprising number of fishes. In California, the Tropical Tuna Commission is now tagging yellowfin tuna, and the California Game and Fish Commission has tagged striped bass and yellowtail. In Texas, the Port Aransas Rod and Reel Club has organized its own tagging of sailfish. In Florida, anglers in the excellent sailfishing areas of the east coast cooperated with The Marine Laboratory, of the University of Miami, some years ago in a research program from which the rate of growth of the sailfish was finally established.

The same laboratory originated the tagging of the giant tuna at Cat Cay and has also worked closely with anglers and fishermen in tagging such varied creatures as tarpon, snook, mullet and spiny lobsters. The U.S. Fish and Wildlife Service has undertaken tagging programs and has cooperated with the Woods Hole Oceanographic Institute in tagging bluefin tuna. In Florida today the anglers continue to tag and return tags from spotted sea trout for the Miami laboratory. The angler himself will probably recollect many other examples.

Help in Other Ways

Less frequently, the angler has aided research by working directly with the scientist in collecting plankton samples, or in sponsoring expeditions. Lou Marron, John Manning and the University of Miami followed the late Wendell Anderson and Yale in expeditions to study the large billfishes off the Pacific coast of South

America. Michael Lerner was one of the first anglers to organize expeditions for the study of big game fishes. Alfred Glassel with Yale University and Edwin Gould with the University of Miami have taken scientists to the Indian Ocean and to New Zealand respectively in order to study the large game fish.

Measuring the Big Ones

At the large fishing tournaments there is always an excellent opportunity for biologists to measure and examine large numbers of fishes that are difficult to obtain in any other way. At Cat Cay, in the Bahamas; Wedgeport; Mazatlán; Ocean City, where the University of Delaware measures and tags white marlin; and at the new Hatteras Blue Marlin tournament, anglers showed the utmost cooperation in allowing ichthyologists to measure, dissect and remove essential organs, and in other ways make use of their catch.

World-Wide Marlin Study

Anglers have been known, after retiring from business to devote their latter years, as Colonel John K. Howard has, to a training in biology, followed by a scientific career in studying the world-wide distribution of the marlins and sailfishes. Others contribute by reporting to the Foundation and to marine laboratories valuable information regarding unusual catches or observations.

In other ways the scientist is in debt to the angler. Yale's Bingham Oceanographic Laboratory, the American Museum field station at Bimini, the new field station at Hatteras and the Miami Laboratory owe their buildings to the financial aid of such ardent anglers as Wendell Anderson, Michael Lerner, Charles F. Johnson, Eric Heckett and George Collier. And there are few ichthyologists who have not benefited from advice, information or specimens freely given by angler and taxidermist Al Pflueger.

Endow Professorships

Big game angler Robert Maytag has endowed a professorship in ichthyology. Others, too numerous to mention, have collected fishes in Panama or plankton in the Caribbean. In all of these varied fashions, and in many others, anglers have rendered the scientist a service which has not always been fully recognized.

The gold medal Anglers Award will be presented at a special dinner which will follow the annual Game Fish Research Conference in November at Miami Beach. The first angler to be honored will be announced shortly, when invitations to the Conference and Presentation Dinner will be mailed to members. It is hoped that the presentation of this award will to some extent demonstrate to all cooperating anglers the appreciation of their scientific friends.

OYSTER SEEDS WILL DIE *if they cannot attach themselves to something solid on the muddy bottom, and the ideal "anchor" is the old oyster shell. Some states wisely require that a certain percentage of the shells of marketed oysters shall be returned to the growing areas. Here workmen are flushing old oyster shells overboard from a barge. (R. M. Ingle)*

Trouble on the Half Shell

By ROBERT M. INGLE
Director of Research, Florida State Board of Conservation

WHEN THE FIRST adventurous souls reached the shores of our Western World there stretched before them a vast and seemingly inexhaustible wealth of natural resources. The lush abundance of plant and animal life, as well as of mineral riches, appeared to be unassessable. They could never be used up, early explorers predicted—an all-time cornucopia for the world!

Today, only about 180 years after the establishment of our nation, we know too well how wrong these estimates were. Prodigious as the mother lode has been, we have pillaged, wasted, raped, ruined and polluted until, in 1960, we are becoming, in many respects, a have-not country.

Oyster a Prime Target

Perhaps no other animal of the many that made up the natural legacy of our continent has suffered as many blows as that friendly symbol of hos-

pitality and abundance—the American oyster.

Even without man's interference, the oyster leads a precarious life. It is beset by a multitude of natural enemies as fond of its flesh as humans are, and it is bedeviled by capricious and disastrous quirks of weather and water conditions. The efforts made by science to understand and combat these have been considerable.

The American oyster lives under rather special conditions. It must have a mixture of fresh water and salt water. One hundred per cent of either is not good. This usually limits the really good growing areas to protected embayments near river mouths.

STATE REGULATIONS *vary, but all oyster shells under a certain size must be returned immediately to the water from which they were taken. Most oystermen will do this anyway, to insure a continuous crop. Measurements are taken at unannounced intervals by conservation officers, however; and oystermen retaining or attempting to market substandard oysters are subject to fines. (R. M. Ingle)*

When Enemies Move In

Among the competitors, with man, for the succulent oyster are a multitude of snails, starfish, crabs, fish and worms. Most of these can thrive only in water of a high salt content. At once we can see the effects of a drought, such as southeastern U. S. experienced from 1948 to 1957. Vast areas where oysters previously lived happily were decimated by billions of invading natural enemies as soon as the rivers' diminished delivery raised the salt content of local bays.

Sea Has Risen

A long range effect of this type is due to the rising of the oceans. In the past 20 years, for instance, the sea level has risen about 4 inches in Cedar Key, Florida. Similar rises have been noted over the entire range of the oyster. As a result, outlying and peripheral oyster beds, which had salinities close to the danger mark, probably became salty enough to allow hungry pests to invade and destroy.

Fungus, a Vicious Killer

In recent years scientists have learned of a fungus disease that attacks oysters, usually in their second year or later, and is able to kill off the populations of entire regions when conditions are favorable to the causative organism. Like most serious oyster pests, this fungus finds higher salinities more to its linking and is especially virulent when temperatures are high.

Oyster babies (known as "spat") are especially vulnerable. They are delicate, and must have just the right combination of factors to survive their first two weeks of swimming existence. While they are drifted about by currents, they are vulnerable to any number of voracious animals which feed upon such small swimming organisms.

The Crisis in Its Life

At the end of the first two weeks of life there develops an awesome crisis in the life of each oyster. It must find a solid object to which to attach, or perish. Countless billions of helpless infants perish in the mud and sand each year for a lack of adequate place of attachment. Development during the early stages also depends upon a sufficiently high concentration of salt in the water. Too much fresh water is definitely bad.

These are normal risks and would operate against oyster populations even if men were not in the picture. Actually, men's activities have piled oyster disasters and catastrophes one upon the other to a considerable extent especially during the past 100 years.

Harbors Best Habitats

First of all, the best habitats for oysters happen to be just the spots that are most desirable for harbors for large ocean-going vessels. The natural harbors have understandably been the basis upon which some of the world's largest cities have been developed. These great centers of population have, in many cases, doomed oyster production in large adjacent areas.

Urbanization is an enemy of oysters. Sewage is usually dumped into the nearest water wholesale. Factories and industries pour caustic and toxic chemicals into streams. Petroleum products, the energy sources for our modern life, inevitably find their way into the oyster's milieu. Dredging of channels and construction of dikes and breakwaters alter currents and change the composition of the water.

No Thought of Future

Any oysters that remain on the state-owned natural beds are greedily scratched from the bottom with seldom any thought for the future. Legally, these public oysters belong to everyone, and the competition on the beds overwhelms the poor bivalves.

Ordinarily, about the same time any local industry is in a state of near collapse a few rather ineffectual laws are passed, but these are, by and large, too little and too late. Also, during the latter stages of the decline, a few provident individuals may begin artificial oyster cultivation to escape the disaster occasioned by the avarice of their fellows.

In cases where all oyster production is not obliterated by the various ill effects attendant to port developments, pollution, changed water conditions, etc., this artificial production of oysters has enjoyed (until the past few years) an annual increase. Slow redevelopment of the industry based on private ownership has usually ensued.

Is Man Wholly To Blame?

So far the story is clear. Man is principally responsible. But is he?

The truth is that the preceding dis-

PATROL BOAT *of the "Maryland Navy." Although Maryland owns the Potomac River from shore to shore, some Virginia oystermen feel that Maryland conservation laws are too strict, and try to operate at night with mechanized equipment which Maryland considers illegal. The result has been an interstate "Oyster War," which erupts into sporadic shooting between Maryland patrol boats and armed poachers. (E. John Long)*

cussion does not include some strange aspects and some mysterious happenings that have puzzled the scientists and exasperated the oyster producers. The survival of the industry may very well depend upon the solution of these baffling occurrences.

Declines in Production

Let's start with one of the greatest enigmas—Long Island Sound. Here, at one time, was a grand demonstration of the triumph of private capital and enterprise over the natural and man-wrought depletion of oysters.

In 1945, Connecticut produced about one and a third million pounds of oysters from cultivated beds. In 1956 this total dropped to about a quarter of a million. New York's private production plummeted from five million pounds to about a million pounds during the same period.

Did urbanization of the metropolitan New York area and attendant deleterious effects proceed at such a rapid rate during these ten years? Apparently not. Did pollution greatly increase and channel changes revise the current patterns during the decade? Probably not.

Strange Lack of Baby Oysters

The most obvious cause of the decline has been an almost astounding lack of baby oysters during this period. Meanwhile, scientists have studied, administrators have pondered, and growers have lost fortunes. But the absence of young oysters remains as mysterious as the disappearance of the Hamelin children into the mountain behind the Pied Piper.

To further mystify all concerned, a relatively large number of baby oysters were produced in the spring of 1958. But another tragedy struck just as mysteriously—most of the babies were eaten by an unprecedented number of voracious starfish. Scientists found that an unusual number of food organisms for the baby starfish were available at just the right time to insure the survival of uncounted millions of the pests. That only moves the solution of the problem one step away. What made all the starfish baby food so abundant? No one knows for sure.

Spat-fall has become a problem in New Jersey as well. Here, seed oyster producers have begun the costly manufacture of chicken-wire bags filled with old oyster shells. These bags, placed on the bottom, seem to attract more oyster settlers than shell spread over the bottom. Although the high demand and price make this operation practical, the effort and expense involved show how desperate producers have become.

Chesapeake Bay has begun to feel the pinch for seed oysters. Last year's set was very poor. In recent years experiments have been carried out using seed from South Carolina. Here again, the high market value of oysters today makes this procedure feasible. So far, the results of tests have been indifferent, but the investigation is continuing.

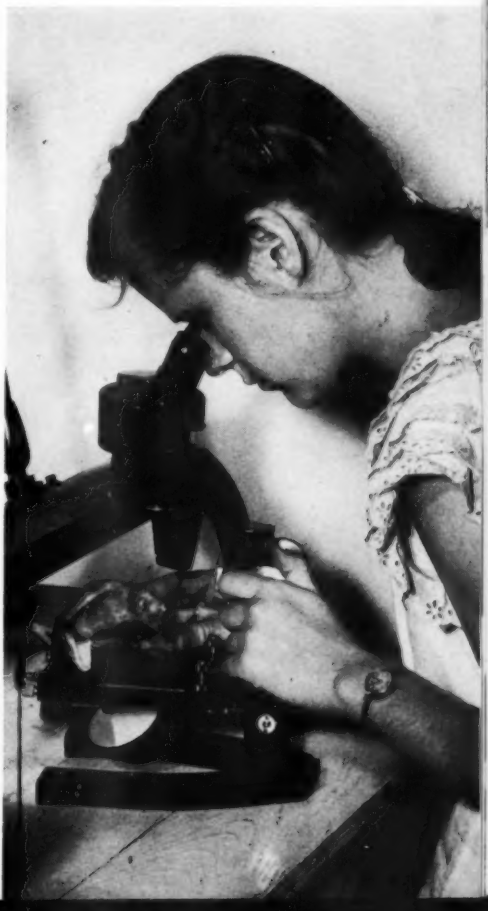
Louisiana also Suffering

Louisiana, long a sterling example of private cultivation, has, in the past ten years, experienced mass oyster mortalities and ever decreasing activity along the rich Mississippi Delta. Much argument has ensued as to just what brought about the debacle.

Oyster men claim that oil companies, whose rigs abound in the tidal waters of coastal Louisiana, have dumped raw oil and accompanying brine (called "bleed water") into the oyster growing areas, thus ruining them. Other cultivators assert that the extensive channel dredging in the marsh (it is easier to dredge channels in the mud than to attempt to build roads) has changed the water conditions and currents.

Oil Companies Join Search

With a previous favorable verdict of $3,000,000 damages against oil companies in the 30's, the combined oyster interests in 1946 sued several



COUNTING BABY OYSTERS *or spat is an exacting task, but it provides data needed by conservationists to determine whether the young are finding a place to develop in sufficient numbers to open or close certain fishing areas. Spat attach themselves to shells, rock, and other solid objects on the bottom, and if conditions are right, they soon grow up to become marketable oysters. (Florida State News Bureau)*

TONGING IS THE TRADITIONAL *and, in some respects, the best way to harvest oysters. While it involves back-breaking work, this method prevents the oyster beds from being depleted or scraped clean of solid objects needed to anchor new growth. Power dredges and other mechanical devices can be very destructive to oyster beds, if used indiscriminately or continuously. (Florida State News Bureau)*

oil companies and other commercial users of the marsh for $46,000,000. This prompted a tremendous scientific effort on the part of the defendants to determine just what did kill the oysters. At one time, one oil company alone had over 100 professional scientific persons on the payroll.

It would be difficult to assess the value of the overall understanding of oysters that resulted from these vast undertakings. But in many minds the issue is still in doubt. These sceptics remind us that we still do not know accurately the effects of seismographic operations. These projects, so essential to oil discovery, utilize dynamite explosions, and resulting shock waves, to study the subterranean rock structures and so identify oil deposits. In Louisiana and other Gulf states thousands of these explosions occur close to oysters each year.

Possible Florida Comeback

In Florida, previously one of the nation's big producers, the industry is practically dead in such urban centers as Jacksonville, Tampa and Pensacola. But in the sparsely populated portions of the panhandle, a very important fact has emerged. Production can be maintained if new beds are established, *but only if the beds are established close to creek and river mouths and the sources of fresh water*. A very careful appraisal of this finding might be worth while.

But more subtle influences could be at work. For instance, the rising oceans. We mentioned the increased salinities of the outlying areas. What about the temperature increase that caused the polar caps to melt in the first place? The temperature difference would be extremely small but cannot be ruled out as inconsequential. Such minute differences in light and temperature have been found to be critical in agriculture and plant cultivation.

The temperature regimes of streams could be expected to be different from those encountered in large bays and coastal sea masses. The latter two would change temperature at a relatively slow rate. It is barely possible that this greater temperature flexibility of streams is one reason why oyster growing areas in Florida are constricting around river mouths.

But the paradoxical fact remains that one of our oldest and best liked salt water animals is suffering a rapid demise and, in most cases, we still do not know what to do about it. Despite the hundreds of millions of dollars that have been spent on oyster research, we apparently have a long way to go. Indicative of our ignorance is the fact that we do not yet know exactly what the American oyster likes to eat.

Nothing short of heroic efforts will transcend our ignorance and give us understanding in time to save one of our most nutritious and valuable sea foods—the friendly oyster.

BARRACUDA AND LOOT. *The stomach contents of a three and a half-foot, thirteen-pound barracuda* (Sphyraena barracuda) *caught off St. John, Virgin Islands, consisted of four recently eaten tagged fish and the remains of another. This marauder was one of several which acquired the annoying habit of feeding on tagged fishes as they were tossed overboard from a skiff by marine biologists. (H. E. Kumpf)*

The Case of the Free-Loading Barracuda

By JOHN E. RANDALL

WHO WOULD HAVE thought the dread barracuda was a lazy fish? Reputedly one of the swiftest, and certainly among the most voracious of sea creatures, it should be capable of obtaining its food by its own efforts, without resorting to handouts. But, at least in the Virgin Islands, there are barracudas which believe in a kind of free-loading welfare state.

It all came to light when The Marine Laboratory of the University of Miami embarked on a study of the biology of reef and inshore fishes at St. John, Virgin Islands. Support for this cooperative marine research venture comes from the Government of the Virgin Islands (as a Dingell-Johnson project), the National Park Service and the National Science Foundation.

Nautical National Park

Since late 1956 a major portion of the island of St. John has been a U.S. National Park, through the kindness of Laurance Rockefeller, who procured the land. The seas adjacent to

the roughly four by eight mile island are consistently clear, and the marine gardens among the more lovely of the Caribbean. The new park plans to rely heavily on the natural beauty of its as yet unexplored corals, gorgonians, and multi-colored reef fishes as visitor attractions. (See "Bahamian Land-and-Sea Park," *Sea Frontiers,* Vol. 4, No. 2.)

One of the phases of the marine research is the tagging of reef fishes. In order to secure information on their movements and growth, these fishes have been captured, mostly in traps, and tagged with disk, dart, and spaghetti tags. The traps are being set in from five to forty feet of water, in five localities in scenic Lameshur Bay, on the south shore of the island. Different colored tags have been used for each of the five localities, so that movement of the fishes may at times be noted by underwater observation.

Barracuda Move In

Not long after the tagging program was under way, barracudas muscled into the act. They learned to linger around the 15-foot skiff from which the tagging is conducted, so that they could easily eat tagged fishes as they were liberated in the sea.

The tagged fishes have almost no chance when a predacious barracuda appears on the scene. Normally reef fishes do not venture far from the shelter of the coral reefs and rock, and probably never come to the surface as adults. None are built for

TAGGED AND READY FOR QUICK RELEASE. *The free ends of a white spaghetti tag, clamped with a numbered monel band, can be seen clearly on this Nassau grouper, recovered in a trap in Lameshur Bay, St. John, Virgin Islands. (John E. Randall)*

BEFORE YOU CAN TAG A FISH *you must catch it. This is the type of wire-mesh fish pot used by the University of Miami's Marine Laboratory biologists in the Virgin Islands during a study of the reef and inshore fishes at St. John. Its contents are being emptied into a wash tub, preparatory to tagging. (Marine Laboratory, University of Miami)*

great speed. Add to this the weakening effects of handling during tagging and measuring. Also the difficulty these fishes have in swimming back down to the bottom after their air bladders have expanded, due to the sudden pressure change when hauled up in the traps, and their plight can be fully understood.

Total War on Fish Thieves

The barracudas apparently realize this and usually engulf the hapless fishes leisurely. Ordinarily a barracuda makes a sudden rush at its prey and not infrequently slashes a fish completely in two with its knife-like teeth, turning back to pick up the halves. But the languid manner of the barracuda when feasting upon tagged fishes makes their interference all the more infuriating to those who labor in the hot sun and rocking skiff to put tags on the fishes. Needless to say, total war has been declared on these thieving fish, which incidentally have proven to be very worthy adversaries.

The first barracuda caught by the

vengeful biologists was a thirteen pounder taken on a hook and line with a small live surgeonfish for bait. It contained four recently-ingested tagged fishes: two surgeonfishes and a parrotfish with disk tags, and a goatfish with a dart tag. The smaller surgeonfish, a blue tang, had a deep cut on its side. The rest were unmarked or but slightly scratched. In addition to these fishes, there were the digested remains of another, and a pair of red disk tags. The numbers on the latter indicated that they had formerly adorned a seven-inch blue tang, which had been recovered in traps four times, the last being four days before.

Five other marauding barracudas, from 8½ to 16 pounds, have been taken, one by a spear and the rest with hook and line. The 16-pound fish had eaten four goatfish with spaghetti tags.

Stalking a Culprit

Two of these barracudas were lost after being hooked, and they were the ones which constituted the biggest problem. One, a fourteen pound three ounce fish, required several months of continuous effort to catch. After being hooked and lost on three occasions, it seemed that it would never take a hook again, although it continued to be just as brazen in its feeding on tagged fishes. Usually it would approach the bait, perceive the hook or leader, and withdraw. At times it would take the bait in its jaws and carry it for a considerable distance. If it felt the pull of the line, it would let go. The barracuda could not be approached closely and attempts to spear it failed.

By placing a man with a powerful spear gun behind a coral head, and utilizing another to herd the fish in the direction of the coral, a single opportunity was provided for a long shot at the fish. The spear struck the fish's head but did not penetrate deep enough to engage the barbs, and it escaped.

For about two weeks no barracuda turned up at the locality where this one had been wounded. Then one of the same size appeared. It seemed to be the same fish, for it was wary from the start, especially of swimmers.

Finally Caught!

During two months the barracuda was master of the situation. The only defense lay in transporting tagged fishes to a shallow place where they could usually reach the coral soon enough to escape it. On one memorable day, however, this crafty fish was finally caught on hook and line. Perhaps it had grown overconfident, if the reader will permit an anthropomorphism. Certainly after the long struggle to catch it, human-like traits were not difficult to attribute to it.

A search of the head where the spear had struck did not reveal any scar. The wound, which probably was a shallow one, had healed without evidence of its existence. This seemed more likely than assuming that a barracuda of the same size could begin the stealing of tagged fish with the slyness of the previous, well-experienced fish. On several occasions, however, a second intruding

NICE PLACE TO WORK! *Palm-shaded white sand beaches, marvelously clear water, and forested hilltops provide an idyllic setting for a study of the biology of reef and inshore fishes of St. John, Virgin Islands, by scientists of The Marine Laboratory, University of Miami. Support for this marine research project comes from the Government of the Virgin Islands (as a Dingell-Johnson project), and the National Park Service and the National Science Foundation. Trunk Bay, St. John, is in the foreground; Tortola, British Virgin Islands, rises in the left background. (Sam Falk, Jackson Hole Preserve, Inc.)*

barracuda appeared within a few weeks at a locality from which one objectionable individual was removed. But never have two barracuda been observed stealing tagged fish at the same time and place.

Sharks threatened the tagging operation on St. John only twice. Three dusky sharks from five to six feet in length were caught before they consumed any tagged fish.

Groupers, on the other hand, have been troublesome. They freely enter fish pots and feed on the smaller fishes entrapped in the chicken wire enclosures. The groupers are tagged like the other reef fishes, but come back to the same traps with exasperating frequency. It seemed that they put up less resistance to handling as time progressed. It was as if they realized that the less difficulty they

caused their captors, the sooner they would be back in the water. But this may all be imagined by the biologists.

Repeatedly Trapped

Some individual groupers have been caught up to twenty times in traps within a period of several months. One large rock hind was recaptured so frequently in a trap that the fish was finally moved 300 yards away before it was released. Two days later it was back in the same trap again.

Just when it was beginning to seem axiomatic that groupers spend their adult lives on one part of the reef and make no extensive migrations, a 20-inch tagged Nassau grouper turned up ten miles away at Buck Island, off St. Thomas, after being caught four times at Lameshur, St. John. The interval between the last St. John recovery and the June 3, 1959 capture at Buck Island was only twelve days.

The groupers which feed on trapped fish have some partially redeeming qualities. The fishes they eat in the traps are usually not tagged, and those they feed on are at least not seen by the biologists. Since these groupers are tagged, information on their growth is obtained each time they are recaptured. So the great barracuda remains the most annoying species to fish taggers, and the problems with it seem without end. As of this writing a new one has appeared in the bay off Beehive Point, and it seems to have the ambition and prospects of becoming the most obnoxious barracuda of them all.

Refuge For Giant Tortoise

One of the world's oldest living creatures, the giant tortoise, may get a new and better lease on life. The International Federation for the Protection of Wildlife plans to establish a special station in the Galapagos Islands, in the southeastern Pacific, to guard giant tortoises from man, dogs and rats. Most of their habitat in the Galapagos has already been set aside as a sanctuary by the government of Ecuador. But, because of the difficulty of policing an area 500 miles at sea, the tortoises are captured by man for sale on the black market as food, or even to zoos. It is hoped that a regularly manned station will protect the big reptiles also from dogs and rats, which dig up their eggs.

In 1928 the New York Zoological Society received permission to send an expedition to the Galapagos to collect breeding stock for distribution to various parts of the world, including Bermuda, Florida, Honolulu, Arizona, Texas, Louisiana and Australia. Those sent to Bermuda and Florida have shown the most promise. Crandon Park Zoo, in Miami, now has five thriving specimens.

The other habitat of the giant tortoise is in the western Indian Ocean, on the isolated Aldabra, Seychelles and Mascarene Islands.

INSHORE SEINING FOR *carp and gray mullet supplements the research work done in deep waters. In winter the yellow croaker is found in great numbers in the estuarine waters to the west of Hong Kong. Of the inshore bottom fishes, the yellow thread is most important. Mackerel, scad, and white herring enter inshore waters in the winter and spring months. (Photo from authors)*

South China Seas

By DAVID BARKER AND F. D. OMMANNEY
Fisheries Research Unit, Department of Zoology
University of Hong Kong

AN EARLIER ARTICLE in *Sea Frontiers* recounted the history and present stage of development of fisheries research in Hong Kong. It now remains to consider future possibilities in this area, particularly in relation to neighboring countries of Southeast Asia.

The fisheries of the South China Sea present a research challenge similar to that posed by the North Sea some sixty years ago. In European waters, however, a long-term concerted attack was possible, with the resources of many nations and research ships in an area possessing a high degree of industrialization, technical skill, and scientific accomplishment.

The South China Sea, by contrast, is bordered by backward people, largely illiterate. Universities of standing are few and far between, most of them being founded and fostered by the West.

Dutch and French Help

Until the creation of the Republic of Indonesia, the Dutch were among the most active contributors, particularly in oceanographical work. The French have contributed in Indo-China, especially through the Oceanographical Institute at Nhatrang, but their influence today is reduced. The Philippines, and latterly Formosa, are both active, deriving their impetus and training largely from America, but their emphasis is mainly on fisheries inshore and inland.

We know little of China's contribution, but there is evidence of research activity based at Hainan, and there have been reports of a combined Soviet and Chinese oceanographical project in this area.

In 1951 the British territories in the area (excluding Hong Kong) contributed, with United Kingdom aid, to the creation of a Singapore Regional Fisheries Research Station. However, five years later, the major contributor, Malaya, withdrew its support on attaining independence and the endeavor collapsed. The Station's research vessel, the *Manihine*, was nevertheless able to carry out useful survey work in the area before the project ended. In 1955 a Freshwater Fisheries Research Station was set up at Malacca, Malaya, and this continues to flourish.

In addition to these activities, a few major expeditions by research vessels which, though not concentrated on the South China Sea, have been near enough to produce monographs useful as research tools. H.M.S. *Challenger* carried out work in the area during her world cruise of 1873-76; the Dutch vessel *Siboga* collected extensive data in the Malay Archipelago in 1899-1900; the Philippine expedition of the U.S.S. *Albatross* 1907-09 yielded the valuable "Contributions to the Biology of the Philippine Arch-

SHOOTING THE SHRIMP TRAWL *from the stern of the* Alister Hardy. *Hong Kong, situated almost at the junction of temperate and tropical waters, is within easy reach of oceanic and estuarine fishing grounds, and is now the most active center of marine research in southeastern Asia. Field studies range from oysters and anchovies to mackerel, croakers, herring and the golden thread. Some twenty-two species of edible prawns, a kind of shrimp, have been found during beam-trawl surveys of the inshore waters around the Colony. (Photo from authors)*

HOME IS THE FISHING FLEET *at Macao, Portuguese island province across the Pearl River estuary from Hong Kong, and drift nets are hung to dry from sampans and junks. More than 8,000 such vessels and twenty Japanese-type trawlers are now crowded in the overfished waters around Hong Kong, due to punitive restrictions placed on other offshore areas by the Chinese Communist government. (Photo from authors)*

ipelago and Adjacent Regions" in the Bulletin of the U.S. National Museum (1917-43); and in 1952, the Danish vessel *Galathea* worked these waters.

Recent political developments in South-East Asia have on the whole tended to reduce fisheries research in the area, and paradoxically enough Hong Kong, the smallest territory and the last to enter the field, now finds itself, with the possible exception of China, the most active marine research center in the region.

The post-war period has seen the first attempt to co-ordinate work in the area through the help of the F.A.O. and the inauguration of the Indo - Pacific Fisheries Council at Baguio, in the Philippines, in 1948. This enabled the backward areas of South-East Asia to be integrated with the advanced fisheries of India, Australia, and Japan.

The Council meets at approximately two-year intervals and has so far held eight sessions, successively at

SAILING ANACHRONISM. *Although the Chinese junk is a symbol of the orient and probably the oldest type of oceanic fishing vessel, it is outmoded and cannot keep up with food needs of the Far East. Fisheries experts at Hong Kong say it must be gradually replaced with some type of trawler, accompanied by exploratory fishing operations to discover suitable trawling grounds. (Photo from authors)*

Singapore, Cronulla, Madras, Manila, Bangkok, Tokyo, Bandung, and Colombo. Other opportunities are afforded at Pacific Science Congress meetings and gatherings such as the International Oceanographical Meeting and Regional Symposium on Physical Oceanography held by U.N.E.S.C.O. in Tokyo in 1955.

Hope in Offshore Waters

So far as Hong Kong is concerned, the future of its fisheries and research lies in offshore waters. The reasons for this are evident in the following extract from the *Hong Kong Annual Report* (1958):

"In 1958 the Chinese Government imposed restrictions on inshore fishing in Chinese territorial waters. Inshore waters were first defined as waters within the 30-fathoms line, but this was subsequently extended. Hong Kong inshore fishermen who have traditionally fished in these waters were allowed to continue provided they conformed with the rules regarding local fishing areas, joined the fish-

ing co-operatives, and marketed 70% of their catch in China.

"Hong Kong fishermen reacted very strongly to these impositions. Several thousand junks returned to Hong Kong waters and are endeavouring to eke out a living by fishing the already overfished inshore waters of the Colony. It is estimated that some 5,000 junks are now concentrated in Hong Kong waters."

The building up of an offshore fleet will be a long-term project, involving the gradual replacement of the junk by some acceptable type of trawler, accompanied by exploratory fishing operations to discover suitable trawling grounds. The *Alister Hardy* is too small to tackle the survey work required; a larger research vessel is essential and accordingly the Hong Kong Government has acquired the research trawler *Cape St. Mary* which will begin operations next year.

The *Cape St. Mary* is a British fisheries research vessel built under the Colonial Development and Welfare scheme in 1951; a vessel of 239 tons, and 117 feet long. She has previously carried out work in West Africa and British Guiana.

Surveys Far Afield

With the *Cape St. Mary* it will be possible to carry out an extensive trawl-ground survey in offshore waters between Hong Kong, Formosa, and the Philippines, and afford an opportunity for extending the oceanographical and plankton - sampling program. The *Alister Hardy* will continue to work in inshore waters and assist with the training of coxswains and fishermen.

If research vessels similar to the *Cape St. Mary* were operating from Formosa, the Philippines, Indonesia, Singapore or Malaya, and Thailand or Vietnam, and if the framework for

CHINESE CREW AND SCIENTISTS *watch as an otter trawl is hauled on board the* Alister Hardy. *This device is used to obtain specimens of bottom fish and other marine life along the sea floor. Other Hong Kong surveys, designed to study catch per unit of effort, must await a larger vessel which can tow full-sized commercial trawls. (Photo from authors)*

co-ordination could be extended to include China, then we could indeed look forward to substantial progress being made. A great step in this direction was taken in January, 1959, when representatives of South - east Asian countries, together with U.N.-E.S.C.O. consultants and F.A.O. observers, attended a meeting in Saigon to consider regional co-operation in marine science.

Prelude to Five-Year Survey?

Plans were outlined for a joint expedition to the area from the Vanderbilt Foundation and Scripps Institution. The leader of the expedition will be Dr. Anton Bruun, world famous marine scientist from Copenhagen, who led the *Galathea* expedition in 1952. He will work with a research ship of 327 tons for two years in the South China Sea and Gulf of Thailand and it is hoped that this will be the prelude to a further five-year survey of South-east Asian waters.

Another project concerned a U.N.-E.S.C.O. training course for marine scientists at the Oceanographical Institute, Nhatrang, from August to December, 1959. The course was intended mainly to familiarize scientists with the special problems of marine research in the area. The Scripps-Vanderbilt expedition co - operated by providing experience and training at sea for those attending. Two Assistant Research Officers from our Fisheries Research Unit attended this course, and we offered full co-operation to Dr. Bruun's expedition, particularly with regard to dovetailing with the survey work of the *Cape St. Mary*.

Premises Outgrown

An exciting future thus lies before the Fisheries Research Unit, which has gained considerable momentum since its small beginning in 1952. The Unit's laboratory premises in the Department of Zoology are rapidly being outgrown and a move within the next few years will become essential. Plans now foresee the creation of laboratories on reclaimed land at Aberdeen in the early sixties, in premises shared jointly between the Unit and the Government Fisheries Division. By then we may well regard the Unit as having graduated to the status of an Institute and the station at Aberdeen may at last become a reality.

"Tallest" Mountains Rise from Sea

Although Mount Everest soars to 29,028 feet above sea level, its slopes begin on a high plateau. Mauna Loa and Mauna Kea, on the island of Hawaii, however, rise 30,000 feet directly from the sea bottom, and are therefore the world's tallest mountains if measured from base to peak. Volcanic action built the mountains, inch by inch, through the ocean and finally more than 13,000 feet above the sea.

All Things to Navigators

Announcement that the U.S. Coast and Geodetic Survey has recently issued a new Coast Pilot caused hardly a ripple in the general publishing world. But it was "big news" to navigators of the coastal waters of California, Oregon, Washington and Hawaii — the area covered by the latest Coast Pilot 7 edition.

A combination atlas, encyclopedia, geography text, and nautical guidebook, the Coast Pilot contains information of importance which cannot be shown conveniently on the standard nautical charts and is not readily available elsewhere, such subjects, for instance, as landmarks, navigation regulations, channels, anchorages, dangers, routes, weather, ice, pilotage, and port facilities.

The Pacific coast has marine and meteorological oddities that are all its own. San Francisco's famous fogs, for example, come in three varieties: the summer afternoon sea fog that forms a cliff of white vapor and moves inland at an average rate of sixteen miles per hour; the tule fog, which is low-lying dense land or river fog that forms on winter mornings and drains slowly seaward; and a nondescript fog, consisting of a mixture of city smoke, dust and vapor, which drifts slowly seaward in the morning and returns as a dark cloud about 1 p.m. before the west wind.

The Santa Ana, a desert wind that blows offshore, usually in or near San Pedro Bay, may reach a speed of fifty-two knots. It gives the mariner little warning and may cause considerable damage, especially to sailing vessels, if the skipper is unprepared for it in this area. Rocks and currents make Pacific coastwise navigation treacherous, especially in thick weather, although some rocks are revealed by kelp, which can be seen on the surface during the summer and autumn.

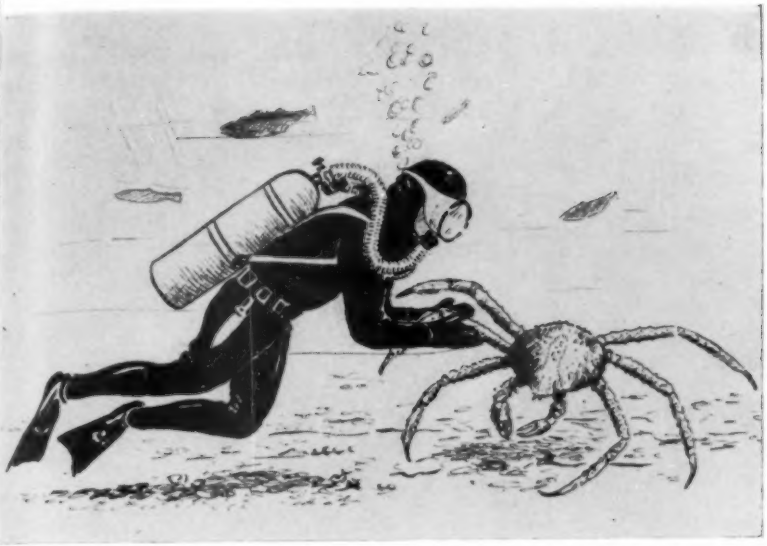
The 383-page book is available at the sales agents, district offices, and Washington office of the Coast and Geodetic Survey. Price, $3.00 a copy.

Fish For Eating, Not Squeezing!

Among proposals for obtaining emergency drinking water at sea is squeezing the body fluids from freshly-caught fish. It is actually recommended in some survival manuals. Now the Royal Navy wishes to explode this myth.

A manually-operated, stainless steel "fish press," capable of exerting tremendous force, was constructed during tests conducted by British naval researchers. Pressure was exerted by a fine-pitched screw ram, turned by an extension lever.

Even with this large and cumbersome device, only a few cubic centimeters of body juice could be obtained from a fair-sized fish. Fish, it would appear, are for eating, not squeezing.



UNDERSEAS "COWBOY." *Little was known about the home life of the giant King Crab of Alaska until skin-diving biologists invaded its domain, herding it into steel-framed, wire-covered corrals on the ocean floor. In this way the entire life cycle of the creatures may be studied. At least once a week scientists descend to feed and observe their charges, some of which may attain a weight of twenty-four pounds and a leg spread of nearly fifty-eight inches.* (Commercial Fisheries Review, *May, 1960*)

"Ranching" The King Crab

Skin-diving biologists at Kodiak, Alaska, have turned to "underseas ranching" for controlled studies of king crabs. The ocean floor is the ranch, steel-framed wire-covered pens are the corrals, and the biologist is the crab herder. The purpose is to gather biological information for the new and thriving king crab industry.

In Natural Environment

The crabs used to be studied after being trapped in pots and hauled to the surface, a method that did not prove very satisfactory. Under the new system, about 300 crabs are confined in six pens, where they can be observed living in their natural environment on the ocean floor.

"Rancher" Submerged An Hour

For his descent, the biologist wears a suit made of neoprene and known to divers as a wet suit. The temperature of the water is about 38 degrees in a 20-foot depth at low tide; although it is even colder at 50 feet, the scientist can work comfortably for an hour at that depth. At least once a week he descends to feed and study his crabs.

Food consists of starfish, sand dollars, sea urchins, and several kinds of bottom fish.

Films Show Moulting

Because he can now observe the moulting process taking place in his undersea pens, the biologist has been able to film the king crab moulting and discarding its old shell. The only time a crustacean can increase its size is during a short period after it has shed its old shell. Comparatively little is known of king crab growth rates but, after hatching, the king crab begins life as a speck of microscopic plankton in the sea and may grow into a 24-pound specimen with a leg spread of nearly 58 inches.

Picking up a king crab can be hazardous for a diver, whose suit may be torn apart as the crab waves its enormous legs and claws blindly about. For that reason, the biologist never handles more than one at a time under water, where they are particularly active.

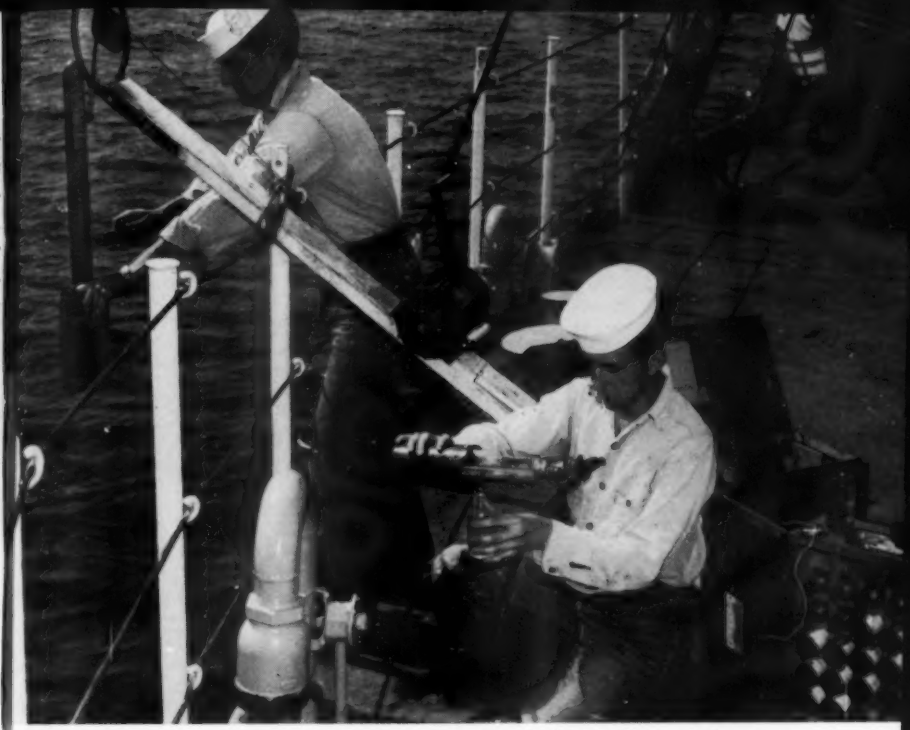
Skin Diving Useful

The director of the project, the Chief of the Biological Research Division of the Alaska Department of Fish and Game, maintains that data on the entire life cycle of the king crab can be obtained by skin diving, and believes that skin diving should be encouraged as a tool in fishery investigations.

Can Computers Avoid Collisions?

The computer, which can refine data much faster than the human brain, is so new that you will not find it listed in most dictionaries. But its development and use have expanded amazingly in recent years. Oil companies determine where to drill, hurricane courses are predicted, rocket and space missile orbits and trajectories are calculated, airline reservations and inventories become quickly known, and the Army works out the supplies needed for a military operation by feeding figures into these wizard-like machines, and then making decisions on the answers they whip out.

Now the Maritime Administration wants to know if computers on board radar-equipped ships might provide automatic warnings of potential collision courses. Bids have been asked for a prototype radar data computer as a part of the Federal agency's program for new navigational aids and safety devices for merchant ships. A computer, in the opinion of one electronics expert, would be more sensitive electrically to what is going on in the radar scope than the human eye. As designed, there would be a warning light and bell activated by the computer whenever one of the radar targets, which has entered into the computer, becomes "critical" or enters a danger zone.



MUCH REMAINS TO BE KNOWN *about the temperature and the salinity of the sea at different levels—information of value in submarine and anti-submarine warfare. Here crew members of a lightship check bathythermograph readings at the entrance to New York harbor. Samples of water taken at various depths are bottled for later laboratory analysis. This is some of the valuable research work discussed in Publication #600, National Academy of Sciences, reviewed below. (U. S. Coast Guard)*

Science of the Sea in BOOKS

Technical Reading

PHYSICAL AND CHEMICAL PROPERTIES OF SEA WATER

PUBLICATION #600. The National Academy of Sciences - National Research Council. Washington, D.C. 202 pages. $2.

This valuable reference book is really a report on a conference sponsored by the Committee on Oceanography of the National Academy of Sciences-National Research Council, for the purpose of reviewing and planning new programs of research on the properties of sea water.

Committees were formed on Field Measurements, Chemical Properties, and Physical Properties. The reports of these committees discuss the present situation, and recommend studies in areas requiring special attention. Included, too, are papers on hydrography, thermodynamics, composi-

tion, biological considerations, and acoustical properties of sea water. Theory, accuracy of available data, and measurement techniques are also discussed.

While the report does not contain detailed tables of data, it does survey the field as a whole, and is therefore a required volume for investigators in this area. E.R.

HANDBOOK OF COMPUTATIONS FOR BIOLOGICAL STATISTICS OF FISH POPULATIONS

W. E. RICKER. Fisheries Research Board of Canada, Nanaimo, B. C., Bulletin No. 119, Ottawa, 1958. 300 pages. $5.00.

Dr. William E. Ricker, among the leaders in studies of fish population dynamics, has prepared this statistical handbook to put in one place the ideas and procedures of various workers. Contributions to this complex field of study have been increasing rapidly in recent years and are found in a variety of journals. But an assembly in one publication is warmly welcomed by the fishery biologist.

In 1948, Ricker prepared "Methods of Estimating Vital Statistics of Fish Populations" (Indiana University Science Series), a publication about one third of the size of the present Handbook. The earlier work is out of print, but everything valuable that appeared there is to be found in the new Handbook. The latter includes most of the basic procedures which came to Dr. Ricker's attention through 1956, with the exception of some from Japan and the U.S.S.R. Worked examples are given for procedures that he feels have been most used, or seem to offer promise of wide usefulness.

Major topics covered are: Estimation of survival rate from age composition; vital statistics from marking—one or more seasons, survival constant or variable; survival and rate of fishing success to catch or effort; stock and mortality estimation from catch statistics and qualitative composition; growth in length and weight; yield computation from given recruitment; relation of recruitment to adult stock size; and direct estimation of relation of equilibrium yield to size of stock and rate of fishing. E.S.I.

General Reading

THE EARTH BENEATH THE SEA

FRANCIS P. SHEPARD. The Johns Hopkins Press. 1959. 275 pp. 113 illus. $5.00.

The seafloor is still one of the least known parts of our planet and therefore remains the last fascinating target for the earthbound explorer. Dr. Shepard's book is written in a popular and easy style and should find a place on the shelf of everyone interested in the ocean and its exploration. Though written for the general reader, however, it also serves the purpose of providing up-to-date information for scientists who are not specialists in this field.

Of especial interest is an eyewitness account of a tsunami, ro "tidal wave." There are also chapters on beach erosion, seafloor canyons, the origin of coral reefs and the structures which underlie the seafloor. Frequent references to the use of skindiving in seafloor studies will make this book particularly interesting to aqualungers. F.G.W.S.

FLASHING HARPOONS — The Story of Whales and Whaling

R. FRANK, JR. Thomas Y. Crowell Company, New York. 1958. 183 pages, numerous illustrations, $3.00.

Although written for the younger reader, many adults will find this ex-

cellent book an engrossing account of whales and the men who hunt them. The first part of the book is devoted to a description of modern whaling operations in Antarctic waters, using explosive harpoons, catcher boats and factory ships.

The story then moves to descriptions of the more common whales found in whaling waters. A history of whaling from the earliest days is also included. The latter part of the book is devoted to the golden age of whaling (roughly 1800-1860) when many New England seacoast communities, of which New Bedford was the most important, were bustling centers of activity for the industry. This section includes not only accounts of some of the more famous whaling voyages but descriptions of the monotonous, lonely, and often dangerous life aboard a whaling ship. No attempt is made to glamorize this aspect of a whaler's existence.

The numerous illustrations by John O'Hara Cosgrave II are a fitting addition to this interesting book.

D. M. D.

About the Authors

ROBERT MAURICE INGLE

Robert Maurice Ingle is well qualified by both experience and training to write of conservation. His present duties as Director of Research, Florida State Board of Conservation, involve planning and supervision of a program which expends some $200,000 annually, the preparation of scientific reports, and consultation with scientists of other states and countries on problems of mutual interest. He also prepares recommendations for inter-state and international treaties.

Mr. Ingle, a native of Illinois, has studied at the Universities of Illinois, Minnesota, Ohio, Florida State and Miami before assuming his present duties at Tallahassee. He holds an M.S. Degree in Biology from the University of Miami. His scientific contributions include papers on shellfish, sea turtles, sturgeon, shrimp, and other marine subjects. During World War II, he served as a malaria control officer and tropical diseases prevention officer at various U. S. Navy stations in the West Indies.

Congratulations

MEMBERS are to be congratulated that their numbers have more than doubled every twelve months in the few years since the Foundation began its work. They are drawn from the United States, Canada, Central and South America, Great Britain, Australia, France, Germany, Italy, Turkey, Denmark, Sweden and Norway as well as a few from the Pacific Islands, the West Indies and Russia.

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THE EDITOR will be glad to consider for publication articles and illustrations covering explorations, discoveries or advances in our knowledge of the marine sciences or describing the activities of oceanographic laboratories or expeditions in any part of the world.

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We urge you to consider membership. An annual membership of $5.00 will defray the cost of printing and mailing of your *Sea Frontiers* and *Sea Secrets*. All other memberships will, of course, provide a measure of support to vital research and scholarships.

According to a ruling of the U.S. Treasury Department, donations made to the Foundation are deductible in computing taxable income as provided for in the 1954 code.

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